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ABSTRACT

Low achieving, low socioeconomic students, because of a multiplicity of little-understood background factors, seem to fail not because of an initial lack of motivation to learn, but because basic learning processes taught them by their own communities are not contiguous with those required for academic success. The study attempts to determine if high-achieving students have developed interrelationships among their cognitive and educative abilities which permit them to acquire cognitive processing systems that are qualitatively and quantitatively different from those developed by low-achieving students, and if such relationships define specific areas of curriculum input that would systematically improve the performance of low achieving students. First, two groups of eighth graders were located through background information and a battery of achievement tests: one a high-achieving high socioeconomic group, the other a low-achieving low socioeconomic group. Then correlation techniques were used in an attempt to model the hypothetical cognitive processing systems. It appears from preliminary findings that low achievers exhibit a poor quality of achievement because they retrieve and integrate inappropriate bits of information into inefficient cognitive processing systems. (Author/JM)

UNDERACHIEVEMENT--A CASE OF INEFFICIENT COGNITIVE PROCESSING

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UNDERACHIEVEMENT--A CASE OF INEFFICIENT COGNITIVE PROCESSING

The achievement of culturally disadvantaged students and of students in low-socioeconomic-status (SES) communities has been the topic of much discussion. Much has been speculated about the ability of these students to achieve, the debilitating effects of their communities, the lack of communication between these students and their parents, their fantasy syndrome, their low self-esteem, and their inferior genetic endowment (Jensen, 1969). The students so designated are predominantly blacks, Mexican-Americans, Indians, or Appalachians who live in large urban or rural areas, whose parents earn less than $4,000 per annum, and whose educational training has been supported by city, state, and federal monies.

In attempting to specify their educational needs, many studies have identified this population of students as a composite of individuals so diverse in ability and capacity to achieve that without smaller classes and the use of more instructional materials, special programs, and exceptional teachers, the probability that they will succeed in school is minimal. However, these studies do not often report that the students initially come to school as eager to learn as other students, nor that they bring to their schools sociological and psychological problems that differ from those encountered in schools of middle- and high-SES communities. Accordingly, very few studies have been conducted in which the researcher investigates whether those patterns of learning which contribute to the students' success in their own community are contiguous with those established by school curricula.

In a paper presented at the 1970 meeting of the Eastern Psychological Association, the author discussed the effects of social reinforcement systems (SRS) on individual and group behavior. It was noted (*a*) that diacritical factors, such as social status, group or class membership, and general social relationships with others, have an impact on an individual's psychological and physiological status, and (*b*) that positive reinforcements are to be preferred because they insure the internal security and stability of the individual. One conclusion derived from this mechanism is that preferred behaviors vary across groups of people because an unequal distribution of social justice and services exists.

Since behavioral responses are correlated with one's environment and particularized by SRS, it is reasonable to expect that new environmental situations (e.g., experiences in the school) would require individuals to reconstruct their perceptual patterns and to use those newly constructed patterns of thought (learning) in such a way that they are compatible with the new environment. This is not to say that the original cognitive patterns of the individual were inferior or distraught, but rather that they were not in consonance with those assumed by the curriculum or educator. It is most probable that the individual's system or method for processing input stimuli in the one case is quite different from the set of assumed or prepared response-stimulus (R→S) patterns to be elicited from a standard set of educational referents. It must be recognized also that students from middle- and upper-SES neighborhoods face the same dilemma upon entry into the schools; however, the number and kinds of transformations they are required to

make are not so acute, since most school curricula are developed within their frame of experiences.

Why is it, then, that the stimuli reaching the brain centers of the contrasting SES students produce different outcomes? One plausible explanation is that students from socially different environments must learn a "new system of cognitive integration." This statement implies that such students face two tasks--they must learn new cognitive systems and they must acquire new learnings. Therefore, learning for these students, in the school setting, constitutes (a) the reconstruction of past patterns of cognitive integration and (b) the application of these new strategies to the resolution of the pending tasks. If, when introduced to a new task, these students are able to generate a strategem that resolves the task, then that strategem or system of cognitive integration becomes a process that provides positive reinforcement for that task. Moreover, that strategem becomes "fixed," and thereby establishes a (reinforcing) pattern of responses to that and/or other related tasks. If, on the other hand, the generated strategem does not resolve the task, the students become more confused and begin (a) to learn to distrust their past referents and (b) to doubt their ability to compete within the new environment [imposed negative reinforcements].

Testimony to this need for selective learning prerequisites has been offered by Harlow (1959), Bruner (1960), Gagné (1961), White (1965), and Staats (1968) in their theories concerning learning hierarchies. Inherent in the concept of learning hierarchies is the process of learning readiness--the internal and external assurances of the learner that he has acquired or developed requisite learnings prior

to the undertaking of new tasks (Ausubel, 1963; Bayley, 1963; Gagné and Boles, 1963; Baller and Charles, 1968; Jensen, 1969). This kind of interpersonal assurance improves the probability that the student will be successful on subsequent tasks. Jensen (1969) indicated that the disregard of readiness may cause

(1) [the student to] learn the subject matter or skills by means of the cognitive structures he already possesses; but because these structures are less optimal than more advanced structures in the sequence of cognitive development, the learning is much less efficient and results in the acquisition of knowledge and skills with lesser capability of transfer to later learning ... and (2) the phenomenon referred to as turning off--an increasing inhibition of the very behaviors that promote learning--[to occur] ... (p. 10).

The taxonomy developed by Bloom (1966) and the structure-of-intellect model of Guilford (1956) provide methods for measuring levels of learning complexity as well as the identification of some of the independent intellectual abilities involved in complex cognitive activities. Although studies have been undertaken to determine whether cognitive abilities, per se, could improve the prediction of specific learnings (Guilford, Hoepfner, and Petersen, 1965; Duncanson, 1966; Horootunian, 1966), evidence was produced that cognitive abilities are not effective as independent predictors, but rather are probably learning-task specific (Stake, 1961) and consist of more basic subabilities (Kelley, 1964).

The integrative nature of hierarchical learning and intellectual abilities is described in a neuropsychological theory by Hebb (1949).

In his theory, complex cognitive functions are created by the interfacilitation of more basic neuronal subsystems. More recent work by Luria (1966, 1969), Beritasvili (1969), and Smirnov and Zinchenko (1969) has confirmed such neuroanatomical and neurophysiological connections. Their studies have shown that the specific configurations of neurological cells not only perform special anatomical and chemical functions but also formulate interconnections between and among other areas of the brain to produce complex subsystems indigenous to particular neurophychological activities and functions. Quantitative neurophysiological studies of Krech (1968), Oken (1967), and Weybrew (1967) have supplied supportive data to indicate (a) that chemical and anatomical changes occur in the brain during learning and thought processes and (b) that the net effect of these changes is to produce intraneuronal networks that improve the transmission of nerve impulses.

The postulates and findings cited seem to provide information that would enunciate a more reliable explanation for achievement. Achievement is a process which involves the application (transfer) of previous knowledges, skills, and experiences to new learning situations. Therefore, precise mechanisms for transfer are developed (e.g., learning sets, strategies, and episodes) which have prescribed inputs (basic knowledges and skills) and a rigorous system for producing subsequent outputs (cognitive processing systems, CPS). The probability associated with the production of a successful output--resolution of a task--is related (a) to the level of participant readiness, (b) to the appropriateness of stimulus inputs, and (c) to the adequacy of the processing system through which input information passes. Underachievement would

occur, therefore, when any one or a combination of the aforementioned parameters is deficient.

Problem

Preliminary studies indicate that low-SES students have low thresholds for perceptual and psychomotor capacities. These difficulties, when combined with the societal diacritical factors described by Deutsch, Katz, and Jensen (1968), produce a multiplicative effect on their achievement. Moreover, if the integration of perceptual and psychomotor stimuli provide crucial inputs for the learning process, students who demonstrate low performances in these areas would appear to have developed CPS which limit their natural abilities to perform effectively in the school setting. If this line of inquiry be credulous, then there are at least two implicit questions which must be addressed if one wants to explain the phenomenon of underachievement in terms of cognitive processing strategies:

(1) Have high-achieving students developed interrelationships among their cognitive and educative abilities which permit them to acquire CPS that are qualitatively and quantitatively different from those developed by low-achieving students?

(2) Could such relationships define specific areas of curriculum input that would systematically improve the performance of students classified as low achievers?

Method

Thorndike (1963) has criticized most studies which attempt

to discover the differences between under- and overachieving students as having been poorly designed. In his discussion of appropriate models, he indicated that most methods used to designate under- and overachievers require estimates of achievement which are based upon other achievement or aptitude test scores. He maintains that procedures which delineate these categories via prediction yield results which are highly prone to error. One design which he considers to be appropriate is the Concurrent Comparisons of Contrasting Groups. This design produces sensitive estimates of systematic differences between the contrasting groups (p. 59).

To create a more practical classification of student achievement, the author suggests a definitional schema for describing the contrasting groups. High achievers are those students from high- or middle-SES environments whose educational experiences, expressed as standardized test scores, indicate that their educational performance is one or more levels above grade expectation. Low achievers are those students from a low-SES environment whose educational experiences, expressed as standardized test scores, indicate that their educational performance is one or more levels below grade expectation. These broad operational definitions were chosen (a) because they appear to be meaningful in identifying some of the major differences between the contrasting groups and (b) because they appear to limit the kinds of immediate errors one encounters when attempting to use aptitude or achievement data to predict levels of anticipated student performance.

Three assumptions are made when using this definitional dichotomy. First, one assumes that the potential for achievement exists within both groups. Second, one postulates that some determinants of

performance are factors which are not explicitly delineated in aptitude measures (e.g., decoding and encoding skills, information processing systems). The third assumption, which is consistent with the position of Deutsch, et al. (1968), maintains that there are specific deprivational conditions which systematically affect the performance of inner-city children (e.g., race, limited perception and verbal experiences, psychological development).

Sample

Eighth-grade students were selected because they represented a population which would (a) have familiarity with school practices and procedures, (b) have knowledges and skills reflective of a somewhat consistent program, and (c) meet the age criterion for valid measurement of the selected cognitive ability tests. To obtain an appropriate sample for the study, the performance scores (Iowa Tests of Basic Skills) of eighth-grade students from contrasting socioeconomic backgrounds within the School District of Philadelphia were examined. According to the definition of high and low achievers presented earlier, two junior high schools were selected. Within each school two classes were chosen which best exemplified, respectively, accelerated and depressed achievement patterns. The mean scores, standard deviations, and comparisons between the dispersions of the two groups are presented in Table 1. This table shows that the average performance score of the high achievers on each

Insert Table 1 about here

subtest is equal to or greater than a grade equivalent of nine and that the average subtest performance scores of the low achievers center around a

grade equivalent of six. Comparisons of the variations between the two groups on each subtest indicate that significantly different ($p < .01$) distributions of scores exist between the groups on the Vocabulary, Reading Comprehension, Spelling, and Language Usage subtests.

To assess more fundamental abilities of both groups, a battery of six cognitive abilities tests was administered. Mean scores, standard deveiations, and *t* comparisons between the groups on each test are presented in Table 2. These data show that the high achievers had attained

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Insert Table 2 about here

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significantly higher ($p < .01$) scores on four tests: Speed of Closure, Numerical Facility, Visual Discrimination, and Maze Tracing Speed.

These biographical data, reported elsewhere in greater detail (Brown, 1970), indicate (*a*) that the contrasting groups fit the definitional criterion stated and (*b*) that measurable differences exist between the contrasting groups on 12 of the 16 variables used in the study. Intercorrelations and reliability coefficients among these variables are displayed for each group in Tables 3 and 4, respectively.

Insert Tables 3 and 4 about here

Instruments

1. Six tests of cognitive ability were used in this study (French et al., 1963). These particular tests were selected because previous studies (in the citations) have indicated that the abilities measured by these tests are associated with learning performance. A brief description of each test follows.

Flexibility of Closure, Cf-2. The ability to keep one or more definite configurations in mind when making an identification of an object in spite of perceptual distractions. This also represents one's ability to allow only the preferred or appropriate images to emerge from a visual field by controlling or minimizing the effects or interferences of extraneous stimuli.

Speed of Closure, Cs-1. The ability to unify disparate perceptual fields into a single percept. This factor differs from Cf-2 in that the subject must construct the image rather than identify it within a distracting field. Speed of Closure is related to one's ability to (a) remember bits of unrelated material, (b) find figures, (c) make comparisons, and (d) carry out visual tasks.

Associative (Rote) Memory, Ma-1. The ability to remember bits of unrelated material. Tests requiring recall of items in isolation do not have a loading on this factor. Although there has been no clear demonstration yet, this factor appears to represent the ability to form and remember new associations quickly.

Numerical Facility, N-3. The ability to manipulate numbers in arithmetical operations rapidly. Tests involving memory for numbers, counting, plotting on graphs, and a host of other tasks load on this factor. Nonnumerical tests having to do with coding have a moderate loading. Sometimes speed of reading and reading comprehension tests are related to Numerical Facility when this factor is considered to be a General Reasoning Dimension.

Visual Discrimination, P-3. A measure of one's speed in finding figures, making comparisons, and carrying out other very simple

tasks involving visual perception. Subfactors have been defined as (a) speed of symbol discrimination (Cattell, U.I.T. #12), (b) speed of making comparisons, and (c) speed of form discrimination as in recognizing predetermined or novel configurations (Guilford, EFU or ESU).

Maze Tracing Speed, Ss-1. A measure of one's speed in visually exploring a wide or complicated spatial field. This ability involves the scanning of a field for openings, following paths with the eye, and quickly rejecting those paths presenting false leads. On some tests, this factor is termed "planning function." The level of planning required by these tests seems to be willingness to find a visually correct path. Others have interpreted this planning capacity as being somewhat analogous to rapidly scanning a printed page for comprehension.

2. The Iowa Tests of Basic Skills (ITBS) battery was given to measure the ability of the students to use specific skills associated with the educative processes of the schools. Only eight subtests were evaluated--a subset assumed to be most closely associated with the attainment of reading and arithmetic performance.

Vocabulary (V). Purpose--to determine whether the students know the meanings of all words within a given item.

Reading (R). Purpose--to measure the student's skill in locating details, finding purposes, recognizing [literal] organizations, and making evaluations of written selections.

Total Language (L). In general, the language section is designed to detect language errors which more clearly differentiate between students who habitually use correct language and those who have not developed functional habits and correct use of the language. Spelling (L-1) items

require the student to identify incorrectly spelled words. Sixteen possible error types are used, ranging from double letters to consonant substitution. Language Usage (L-4) measures the student's knowledge and use of appropriate word forms and correct grammatical constructions. Items discriminate between those students who know and use good grammar and those who know but do not use correct English.

Reading Graphs and Tables (W-2). Students are asked to obtain information from five different graphs or tables. Such presentations include traditional displays and pictographs.

Knowledge and Use of Reference Materials (W-3). The student's ability to deal with the parts of a book, the globe, current magazines, dictionary, encyclopedia, atlas, etc., is measured. Activities involve the use of the index, dictionary guide words, key words, alphabetizing words, using the dictionary for spelling, syllabification, accentuation, etc.

Arithmetic Concepts (A-1). The student's understanding of the logic of the computational process is tested where the emphases are on the understanding of numerical systems, of terms, processes, and operations, of geometric concepts, and of units of measurement.

Arithmetic Problem Solving (A-2). The student's computation skill is tested in a meaningful setting. His competence is tested in a functional setting with problems chosen to be challenging and practical. However, the major skill categories are the same as those for subtest A-1.

Procedure

In an effort to understand better how cognitive and educative

abilities interrelate to produce the successful attainment of reading and arithmetic performance in eighth-grade students of contrasting backgrounds, a comparative study was undertaken by Brown (1970) to identify and describe characteristic cognitive-educative intercorrelates (CEI) which best distinguish the characteristics of students performing above their grade expectation (high achievers) from those performing below grade expectation (low achievers).

In this study, the correlation values obtained from measures of cognitive and educative abilities of high and low achievers were compared and studied. By definition, the exemplary performance relationships (correlation values) of the high achievers represented the most appropriate CEI for producing successful achievement outcomes. Likewise, the CEI's of the low achievers were considered to be educationally deficient when the observed correlations were smaller than those exhibited by the high achievers. Under this condition, low achievers had not integrated the components into the prescribed functional relationships. When the CEI's of the low achievers showed correlation values which were greater than those of the high achievers, fundamental educational dependencies were indicated. These kinds of dependencies describe situations where the students depend heavily on subabilities or skills to solve complex problems. CEI patterns for reading and arithmetic are shown in Figures 1, 2, and 3.

Insert Figures 1, 2, and 3 about here

Homomorphic Psychometric Model

The data, theories, and findings cited in the previous section

seem to imply the existence of cognitive systems--that is, systems which integrate information (historical and cognitive) and activities (motor and physiological) for the solution/resolution of a proposed (perceived) problem. If CPS exist, then there should be a technique for showing the existence of and interrelationships among the contributory elements (variables). It is proposed that correlation techniques can be used to simulate (a) neurophysiological relationships among anatomical structures and (b) psychological hierarchies of learning, since such techniques can demonstrate the strength of associations among elements (variables). Table 5 shows a hypothesized homomorphic psychometric model (HPM) which

Insert Table 5 about here

translates simple and complex correlation data into an organized body of knowledge for studying the phenomena of CPS. Entries in the table enumerate the analogues of the HPM across (a) collective neurophysiological classes and (b) several current psychological theories which report either a cognitive processing system or hierarchies of integrated knowledge, skills, or learnings.

A conceptual representation of the HPM appears in Figure 4.

Insert Figure 4 about here

In this figure, zero order correlations represent integrations between two sources of variable stimuli. The intersection of a series of r_{xy}'s, (R_{xy}), shown at the center of the rectangular configuration, represents a phase or cluster of small, discrete stimuli with specific functions. R_{xy} cords are equivalent to cognitive aggregates which are externalized

in the performance of a task. R_{xy}'s are composite roots through which pass a variety of exorganismic functions. The characteristics of the root functions can be identified through factor analytic procedures where (a) each factor cluster corresponds to a major information processing output, (b) the loadings represent the proportion of the quantifiers (predictor variables) involved, and (c) the prominence of a factor cluster represents the extent to which that factor occupies a priority within the root.

Theoretical Hypothesis

In summarizing this theoretical position, the following operational hypothesis is derived: Correlation values are numerical expressions which express the probable interfacilitation among the observed elements (variables) within a hypothetical cognitive network system.

Lemma 1. Correlation values are indicators of neuronal interfacilitations. At least five levels are proposed:

Level 1: correlations between cognitive factor variables.

Level 2: intercorrelations among cognitive factor variables.

Level 3: intercorrelations among cognitive abilities and specific educative (basic) skills.

Level 4: intercorrelations among educative (basic) skills.

Level 5: intercorrelations among cognitive abilities and educative (basic) skills.

Lemma 2. Derived correlation values represent the state of neuronal interconnections. High values indicate either (a) a highly specialized association among cofunctional elements or (b) a high

involvement of participatory elements to produce requisite excitatory potentials. Low values represent either (a) a common (integrated) unilateral or unidirectional input/output function with a variety of lesser elements subsumed under it, or (b) an interaction among the contributory elements producing a minimal level of excitation.

A similar conceptualization for demonstrating interconnections within the cortical areas of the brain has been introduced by Livanov (1969). In his system, correlations between areas of the brain during mental work were obtained through electroencephalography (EEG). He found that low or easy tasks evoked no correlation outputs and that high EEG correlations were produced only in cases where the subjects were given rather difficult tasks (pp. 730-731).

Lemma 3. Predictor elements (variables) are those elements which participate in the formulation of an appropriate pathway through the indicated network for the resolution of the stimulus task (criterion).

Lemma 4. Positive correlation values are indicative of additive excitatory input/output of the system.

Lemma 5. Negative correlation values are indicative of additive inhibitory input/output of the system.

Lemma 6. Total explained criterion variance is equivalent to an absolute proportional (excitatory) value expressed by a quotient (inputs/outputs) of the contributory elements (variables).

Research Hypotheses

There are CPS which have unique qualities for processing incoming and outgoing information stimuli such that (a) the incoming stimuli are intelligible to the organism and (b) the outcoming stimuli

increase the probability of the organism's maintaining, resolving, or terminating pursuant problems, tasks, or conditions. More precisely, CPS are integrated systems (circuits) which receive signal or information inputs over predefined afferent templates (paradigms) and which emit outputs over conditional efferent templates (paradigms) that tend to become more efficient transversal routes across the labyrinth (circuit of the system) in pursuit of a logical and expedient solution to the given problem, task, or condition. Micro-CPS also exist which represent primary decoding and encoding processes for perceiving, assimilating, cataloguing, and storing fundamental stimulus information.

If conditional efferent templates (paradigms) exist, there must be at least one configuration over that system which is more effective and efficient in solving particular kinds of problems, tasks, or conditions than others. Moreover, there must be at least one unique subset of interrelationships among the contributory elements (observed cognitive and educative variables) which would characterize an optimal integrative system. An optimal integrative system is operationally defined by CEI patterns. Therefore, information obtained from the HPM should demonstrate that

1. Qualitative differences exist between CEI patterns obtained for reading and arithmetic performance, as indexed by grade equivalent scores on subtests of the Iowa Tests of Basic Skills;

2. Quantitative differences exist between the reading and arithmetic CEI patterns for students designated as high or low achievers;

3. Quantitative differences exist between the aggregates (R_{xy}) found to predict the reading and arithmetic performance of the

contrasting groups;

4. Quantitative differences exist between the proportions of explained cognitive and educative component variances of the contrasting groups for the three criterion variables used; and

5. Quantitative differences exist between the root functions (factor clusters) of the contrasting groups on the variables studied.

Data Analysis

Procedure 1

Zero order correlations were obtained through the generation of intercorrelation matrices--one for each group.

Procedure 2

A stepwise regression analysis procedure, facilitated by BIOMED program BMD 02R, was used to obtain prediction equations for each group on each of three criterion measures: Reading Comprehension (R), Arithmetic Concepts (A-1), and Arithmetic Problem Solving (A-2). Stepwise procedures were used in preference to multiple prediction procedures because previous data gave evidence that the best predictors for each group on each criterion might not be those traditionally thought of as being relevant contributors. Moreover, the stepwise procedure permits each variable to enter the equation by predetermined parameters (F values for variable entry and deletion).

Draper (1966), discussing the applications of regression analysis, indicated that this technique of variable entry and deletion provides a judgment of the contribution made by each variable as though it had been the most recent variable entered, irrespective of its actual

point of entry into the model (p. 171). F levels of inclusion ($p < .01$) and deletion ($p < .05$) were used (a) to force as many variables as possible into the equation, (b) to permit maximum discrimination among the variables included in the equation, and (c) to identify those variables which are most closely related to the prediction of the criterion measures for each group. After the "saturated" equations were obtained and studied for contextual characteristics, an analysis for significance of loss due to the elimination of prediction variables ($p < .05$) was applied following the procedure of Wert, et al., (1954, pp. 226-255).

Iteration A. All cognitive variables (N=6) and the vocabulary subtest (ITBS) were used to predict performance scores of each group on the three criterion measures.

Iteration B. Thirteen of the 14 variables used in the study were regressed against each criterion measure for each group. Since the groups represented contrasting achievement characteristics, the combined data was used to obtain comparative and validity checks for each criterion measure.

Procedure 3

Group and combined factor analyses were performed to identify the basic factors underlying the variables studied. BMD 03M was used, where the highest intercorrelations were used as communality estimates.

Iteration A. Basic skill data from each group were analyzed. It was hypothesized that four significant factors would be derived from the data, each of which would correspond to the four general skill areas identified by the ITBS: Reading (R), Total Language (L), Work-Study

Skills (W), and Total Arithmetic (A).

Iteration B. Data for each group, and the combined data, were analyzed again using the cognitive and educative variables (N=14). It was anticipated that in addition to four general skill factors there would be at least four cognitive factors: Cf, Cs, P, and Ss. However, it was hypothesized that unique combinations of cognitive and educative functions would be generated as cognitive processing units specific to the functions of the designated groups.

Results and Discussion

Procedure 1

Zero order correlations have already been shown in Tables 3 and 4. The CEI patterns generated from these correlations for high- and low-achieving students have been shown in Figures 1, 2, and 3. These figures showed (a) that each criterion measure had a different CEI pattern, (b) that associations among the variables differed significantly between the two groups with the greatest number of differences being present in the CEIs for A-1, and (c) that most differences occurred between associations with the cognitive variable N and the educative variables L-1, W-2, and W-3.

Procedure 2

Qualitative and quantitative differences were obtained from the stepwise regression procedure used to predict the R, A-1, and A-2 performance scores of the contrasting groups. In iteration A, six cognitive variables and the vocabulary subtest of ITBS were used as the predictor variables. The output of these analyses is shown in Table 6.

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Iteration A. 1. Reading comprehension. The maximum number of predictor variables for the high achievers was 3; for low achievers, 5. Within the significant equations, two variables were identified for the high achievers and three for the low achievers (See Figure 5). The

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educative variable V was a common contributor to both equations. A larger proportion of total group variance was accounted for by the cognitive variables of the low achievers than by those of the high achievers.

2. Arithmetic concepts. The maximum number of predictor variables for the high achievers was 4; for the low achievers, 5. Twice as many variables appeared in the significant equation of the low achievers as for the high achievers (See Figure 6). Variables appearing

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in the equations are qualitatively different. Six times as much total group variance was accounted for by the cognitive variables of the low achievers as by those of the high achievers.

3. Arithmetic problem solving. The maximum number of predictor variables for the high achievers was 5; for the low achievers, 6. In the significant equations, two variables appeared for each group. They are shown in Figure 7. The cognitive variable N was a common contributor

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Insert Figure 7 about here

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to both equations; however, the proportion of variance associated with it in each group varied considerably. About four times as much total group variance was accounted for by the cognitive variables of the low achievers as by those of the high achievers.

Iteration B. To identify those variables used in the study which best predicted the criterion measures across the groups, prediction equations were derived from the combined data. Figure 8 shows the results

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of these analyses. For each of the criterion measures, commonly hypothesized variables appeared as the best predictors. For reading, the variables were V, A-1, L-4, N, Cs, and Ma; for arithmetic concepts, the variables were A-2, R, W-3, L-4, and V; and for arithmetic problem solving, A-1, L-1, and P.

Individual analysis for the groups showed qualitatively different configurations. In most cases, the maximum number of predictor variables appearing for the high achievers exceeded that of the low achievers. However, low achievers had a greater number of variables in their significant equations.

1. Reading comprehension. The maximum number of predictor variables obtained for each group is shown in Table 7. The predictor

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variables comprising each significant equation are presented in Figure 9.

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The educative variable V was a common contributor to both equations. Numerical facility (N)--in this case decoding--language usage (L-4), and the use of reference materials (W-3) appeared as significant variables for the prediction of low achievers' reading performance. The predictor variables of the high achievers accounted for 53% of the total group variance; those of the low achievers constituted a level of 76%.

2. Arithmetic concepts. The maximum number of predictor variables regressed for each group is shown in Table 8. The predictor

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variables comprising each significant equation are shown in Figure 10.

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Hypothesized predictor variables accounted for 79% of the total group variance of the high achievers. Qualitatively different variables appeared for the low achievers, ranging from numerical faciltiy (N) to closure skills (Cs). Collectively, these variables accounted for 86% of their total group variance. Noticeably absent from these predictors, however, was A-2--arithmetic problem solving skills.

3. Arithmetic problem solving. The maximum number of predictor variables regressed for each group is shown in Table 9. The predictor

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variables comprising each significant equation are shown in Figure 11.

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The variables associated with the prediction of the high achievers' performance were consistent with those normally associated with this function--namely, A-1, N, and P.

Although four variables appear in each equation, only one of those associated with low achievers' performance--numerical facility (N)--was related to accepted expectations. Two other unexpected variables, W-2 and W-3, which are indices of how well one is familiar with and capable of using the synthetical context of prepared materials, were also highly significant contributors. The last variable, R, although meaningful, was expected to contribute more favorably to the prediction of A-1.

The variables associated with the prediction of arithmetic problem solving ability of high-achieving students accounted for 80% of the total group variance; corresponding variables accounted for only 61% of the low achievers' performance.

At this level of variable integration, the differences between the contrasting groups become more evident. Table 10 summarizes these

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Insert Table 10 about here

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differences. The table shows the proportions of the observed variation in R, A-1, and A-2 that can be attributable to (explained by) the characteristics of the predictor variables, as they interrelate with the learning styles of the groups. As anticipated, the inclusion of the educative variable did improve the predictability of the criterion

scores. However, the proportion of change seemed to be a function of the achievement group and the criterion being measured.

Different levels of significant gains were realized from the two prediction equations developed for each group on each criterion measure. The addition of educative variables produced significant changes ($p < .01$) in the level of predictability of high achievers' performance scores in A-1 and A-2. For low achievers, these changes effected, to a lesser degree ($p < .05$), the (values of the) saturated A-1 and A-2 equations.

Figure 12 gives a visual representation of these proportions

Insert Figure 12 about here

of explained variances. This figure shows that cognitive variables accounted for a significantly greater proportion ($p < .01$) of the qualitative and quantitative characteristics of the low achievers' regression equations than those of the high achievers. In reading, educative variables represented only a small proportion of the total explained variance. It is interesting to note that other variables not included in this study (e.g., psychomotor abilities, eye movement) represent different proportions of unexplained variance--low achievers = 24%, high achievers = 47%, or nearly twice that of the low achievers. The magnitude of this difference could imply either (a) that the high achievers have combined twice as many other requisite abilities and skills for reading than have the low achievers or (b) that the high achievers are utilizing an integrative reading complement which is twice as effective or efficient as that of the low achievers.

The phenomenon described above is demonstrated more explicitly in arithmetic operations. As in the previous case, cognitive variables account for significantly more of the explained low achievers' variance than of high achievers' variance. The constant predictive proportions of the high achievers (cognitive = 11%, educative = 80%) produce a fixed improvement quotient, 69%, that relates directly to an organized CPS which facilitates (a) the understanding and use of educative abilities and (b) the transfer of continuous knowledge, operations, and skills. That is, arithmetic conceptual knowledge was used in the solution of arithmetic problems; and problem solving knowledge enhanced the understanding of arithmetic concepts (see Tables 8 and 9). Therefore, although the set of cognitive variables in the regression equations differ somewhat (see Figures 6 and 7), 95% of the explained variance in both cases is associated with the same variables (A-1 or A-2 = 76%, P = 1.5%).

Low achievers, on the other hand, did not use the abilities described in A-1 and A-2 to demonstrate their knowledge of arithmetic concepts or to solve arithmetic problems directly (see Tables 8 and 9). Their saturated prediction equations show that the abilities of A-1 and A-2 are used in the overall process, but not to a significant degree. How then do low achievers learn arithmetic concepts and arithmetic problem solving techniques? Within the hypothetical structure proposed by this study, low achievers develop unique CPS which consist primarily of cognitive abilities and work-study skills. The data of this study seem to indicate that the work-study skill W-2 and the cognitive skill N are the common elements that permit the transfer of arithmetic knowledge, skills, etc. However, this transferability seems to be disproportionate

and unidirectional, going primarily from A-1 to A-2. The larger contribution of educative variables to A-2 appears to be related to their needs to interact with the verbal syntax in which materials is presented (R and W-3). The performance scores of these students have demonstrated that these CPS do not represent either effective or efficient methods for attaining arithmetic competencies.

Procedure 3

A number of revealing findings resulted from the factor analyses of both the combined and individual groups. Although a minimal level of 0.3000 was selected to represent a meaningful contribution of a loading to a factor, two levels of involvement were formulated:

$$1.0000 \geq L_1, > 0.4000 \geq L_2 > 0.3000.$$

L_1 represents major loadings; L_2 represents marginal loadings. (Essential summary data for the factor analyses appear in the Appendix.)

Iteration A. Factor analysis of the high achievers' data (Table 11) produced the hypothesized general skill factors. Two general

Insert Table 11 about here

synthetical factors emerged from the low achievers' data. These factors were identified as synthetical in that the two work-study skills had high loading along with those of the verbal and numerical variables.

When the coordinates of the variables in the work-study (Factor I) and the language usage (Factor IV) skills of the high achievers were plotted (Figure 13), four general skill clusters were

Insert Figure 13 about here

formed. Each cluster was distinct and contained those subtest components which described the particular skill.

When the coordinates of the two general factors of the low achievers were plotted (Figure 14), two general clusters were derived

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Insert Figure 14 about here
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which tended to form an educative ability continuum, where one extreme represented a verbal component and the other a nonverbal (numerical). Each of the two work-study tests tended to be associated with that extreme which exemplified the fundamental operations of the work-skill W-2 appeared with the nonverbal cluster in that most operations relating to its functions are expressions in the numerical mode. W-3 appeared with the verbal cluster in that most of the operations relating to its function are expressions in the literary mode.

Iteration B. 1. Combined. The factor structures obtained from the combined data indicated that R, A-1, A-2, W-2, and W-3 were not unifactor tests. However, each cognitive test, with the exception of Cs and N was unifactor having loadings between .8446 - .9787. The factor matrix of the combined groups is shown in Table 12. In addition to the

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Insert Table 12 about here
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hypothesized cognitive factors, three complex factors were observed. One factor was identified as General Educative Skill (Table 13), since

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Insert Table 13 about here
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seven of the eight ITBS subtests had major loadings, with closure and

numerical abilities as marginal loadings.

The other factor was identified as General Arithmetic Operations. The variables loading on this factor are given in Table 14. This factor

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Insert Table 14 about here
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has its highest loadings on arithmetic variables and marginal loadings on a "reading-searching techniquė."

When the coordinates of these two factors (Factors I and VI) were plotted (Figure 15), two psychological continua, representing the

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Insert Figure 15 about here
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two test areas, were produced. The educative and cognitive ability continua appeared to be unidimensional; however, these data were not subjected to a scaling procedure.

2. High achievers. Six factors were recognized from the analysis of the high achievers' data (see Table 15). Unifactor educative

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Insert Table 15 about here
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tests were found to be R, V, L-4, A-1, A-2, W-2, and W-3. Unifactor cognitive tests were Cs, Ma, N, and P. Two factors arose as distinct educative factors: Factor V, Reading (R = .7411, V = .7668) and Factor III, Arithmetic (A-1 = .8932, A-2 = .8952). Two factors appeared with cognitive and educative loadings: Factor I, which incorporated study skills with the closure ability, Cf = .4136 and Factor II, which incorporated language skills with numerical facility (decoding), N = .6772.

Two general cognitive processing skills (CPS) were evidenced.

The first of them, CPS-A (Factor IV, Table 16), appears to represent

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Insert Table 16 about here
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one's ability to translate bits of information through the processes of interrogation, scanning, and integration. The second cognitive processing skill, CPS-B (Factor VI, Table 17), appears to represent one's

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Insert Table 17 about here
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ability to retain bits of information in a variety of discrete seriations or combinations within the totality of some predefined structure. The latter factor seems to be related to the process of spelling.

When the coordinates of the educative factors (Factors III and IV) were plotted (Figure 16), two distinct clusters were formed:

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Insert Figure 16 about here
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an arithmetic and reading. The remaining variable coordinates clustered near the origin, thereby indicating that their functions were not operationally contiguous with those of the former. Moreover, these results imply that the reading and arithmetic functions of this group are well defined operations. Factors CPS-A and CPS-B seem to be functions which could be generalized over many operations.

3. Low achievers. Four factors were generated from the low achievers' data (See Table 18). Two general factors closely paralleled

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Insert Table 18 about here
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those obtained from the analysis of the eight ITBS subtests. The

inclusion of the cognitive variables appears to have made the two general synthetical factors become more resolute. Table 19 shows (a) that the

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Insert Table 19 about here
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values of the major loadings of the verbal-synthetical factor have increased and (b) that two marginal components have been added--A-1 and N. The general numerical-synthetical factor (see Table 20) remained

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Insert Table 20 about here
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essentially the same. Only two educative and threee cognitive variables appeared as unifactor tests: L-4, A-2, Cs, Ma, and Ss. Moreover, most of the cognitive variables had loadings less than .6000.

Two cognitive processing skills appeared, CPS-C and CPS-D. Table 21 shows the variable loadings of CPS-C, which seems to be associ-

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Insert Table 21 about here
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ated with the attainment of arithmetic concepts. Collectively, CPS-C represents one's ability to organize and/or reconstruct bits of information into a somewhat logical order or form prior to the process of closure. CPS-D appears to represent one's ability to remember and discriminate among previously organized bits of (verbal) information (see Table 22). The latter ability seems to be associated with the

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Insert Table 22 about here
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process of spelling. No CPS appeared without educative variables.

When the coordinates of the general synthetical factors

(Factors I and IV) were plotted (Figure 17), the two hypothetical psycho-

Insert Figure 17 about here

logical continua, evidenced in the combined group data, were produced. This finding seems to imply that the low achievers had not been able to integrate the underlying commonalities of these continua into discrete functional units. Indeed, it appears as if the psychological continua are invariant in that no further delineation of specific skill functions was evidenced. Moreover, even the two major functional systems--verbal and nonverbal--had not been refined to those speciffied in the subtests. The operational functions defined by CPS-C and CPS-D seem to confirm the previous assumptions, since they represent the need to discriminate among bits of previously stored verbal information.

Summary and Conclusions

The results of the data analyses seem to support the existence of the proposed CPS. The cognitive network analysis, achieved through the HPM, showed that differential hierarchies of associations exist among the dependent variables used to assess the achievement performance of the two groups. Although all of the lemmas of the proposed theoretical structure were not confirmed by this study, the assumption concerning the existence and function of conditional efferent templates (paradigms) for processing cognitive information seems tenable. The qualitative and quantitative differences between the CEI patterns of the high and low achievers imply that significantly different levels of integration among the variables contributed to the performance levels of the two groups.

Moreover, these data showed that markedly different patterns of associations existed for each criterion task.

At the next level of variable integration, when the contributions of educative and cognitive variables were considered, it was observed that a different set of significant predictor variables was obtained for each group on each performance task. Regression analyses showed not only that the cognitive variables were better predictors of the low achievers' performance but also that these values remained essentially the same in all cases except one, A-2. Moreover, it appeared as if the low achievers had developed CPS which were predominantly integrations of cognitive abilities and work-study skills. Analyses of the prediction of arithmetic competencies showed that the two reference arithmetic tests, A-1 and A-2, were not primary predictors of their arithmetic functions.

For the high achievers, however, appropriate educative variables contributed significantly in all cases. Significant improvements in prediction appeared to be related to CPS achieving transfer functions. The low, persistent level of cognitive variables in the prediction equations suggest that they were CPS transfer facilitators which transferred contiguous processing functions. This was evidenced by the equivalent proportion of variance which existed between A-1 and A-2.

At the next level of analysis, the plot of the major factors of the high achievers demonstrated that the criterion tasks were discrete, functional operations (Figure 13). Confounded operations were obtained from the plot of the low achievers, where both syntax and/or format of the materials and the fundamental abilities are being used to extrapolate

the intended operation (see Figure 14).

When the combined data for all variables were factor analyzed and then plotted, a psychological continuum for each of the test areas was obtained. Plotting of the criterion factors of the high achievers demonstrated that they had developed well defined arithmetic and reading functions. In contrast, the plot of the low achievers' general factors seem to indicate that they had acquired a structural psychological invariance which inhibited their capacity to formulate appropriate integrative units for reading and performing arithmetic operations.

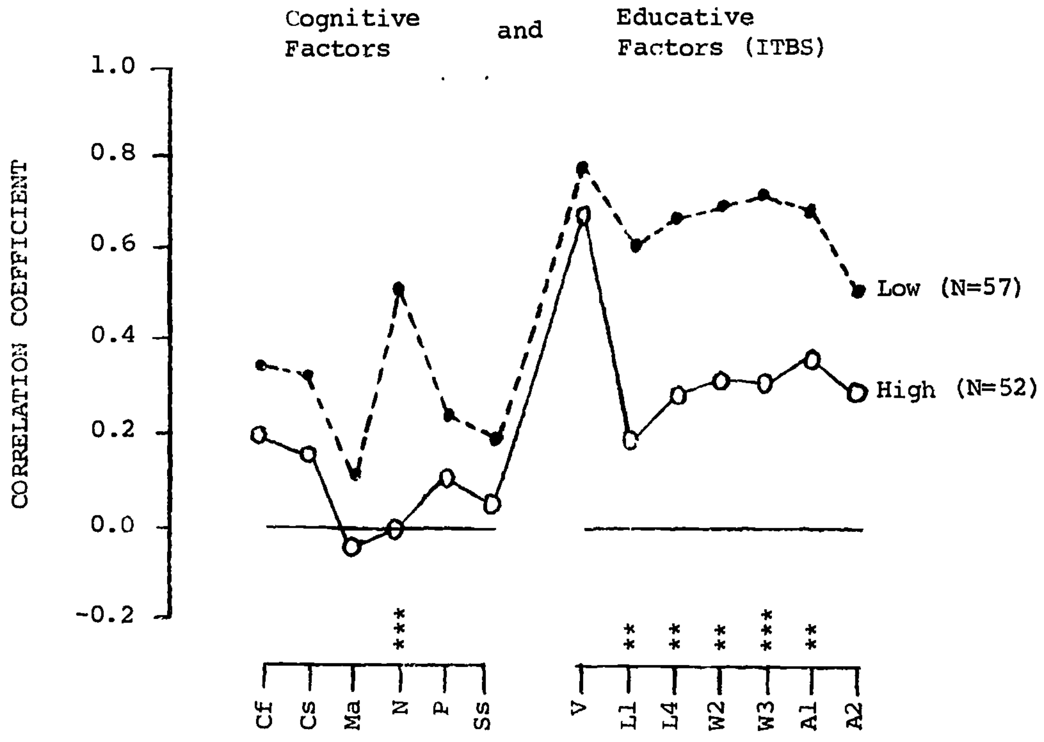
According to the postulated theory, these factor plots indicate that the major contributors (roots) that participated in the expression of each group's achievement performance on the criterion measures were qualitatively different. The high achievers had developed CPS with conditional efferent templates which integrated and transferred appropriate bits of information in the execution of the specified tasks. Low achievers had developed CPS with conditional efferent templates which scrambled undifferentiated bits of information in the performance of the specified tasks.

It appears from these preliminary findings that low achievers exhibit a poor quality of achievement because they retrieve and integrate inappropriate bits of information into inefficient CPS--that is, their CPS represent unique methods for analyzing and/or solving problems which were derived from a sophisticated use of cognitive skills rather than a sequential arrangement of prescribed educative activities which have proved historically to be highly reliable.

These data suggest that the speed and accuracy of low achievers'

performance is a function of how well their contrived system can meet the learning situation. It appears that their system is effective during their early elementary experiences where concrete operations predominate; however, at the upper grades when previously learned knowledges and skills are to be transferred to the new situation, their system falters.

The findings of this study imply that low achievement is not necessarily a function of low intellectual ability, but more probably a function of how well children can transfer their early school experiences (knowledge of basic concepts and their interrelationships) to new situations. Those instructional strategies (a) which acknowledge the fact that children come to school with different levels of cognitive development and requisite experiences and (b) which encourages the attainment of requisite knowledge and readiness skills prior to the undertaking of new and more complex tasks (e.g., the principles of nongrading) best prepare children of varying backgrounds for more successful school experiences. Others which assume a predetermined experiential level appear to encourage the development of pseudo-CPS which evolve into inefficient cognitive transfer agents.



** = Significant at the .05 level

*** = " " " .01 level

Figure 1. Reading comprehension CEIs of high- and low-achieving eighth-grade students.

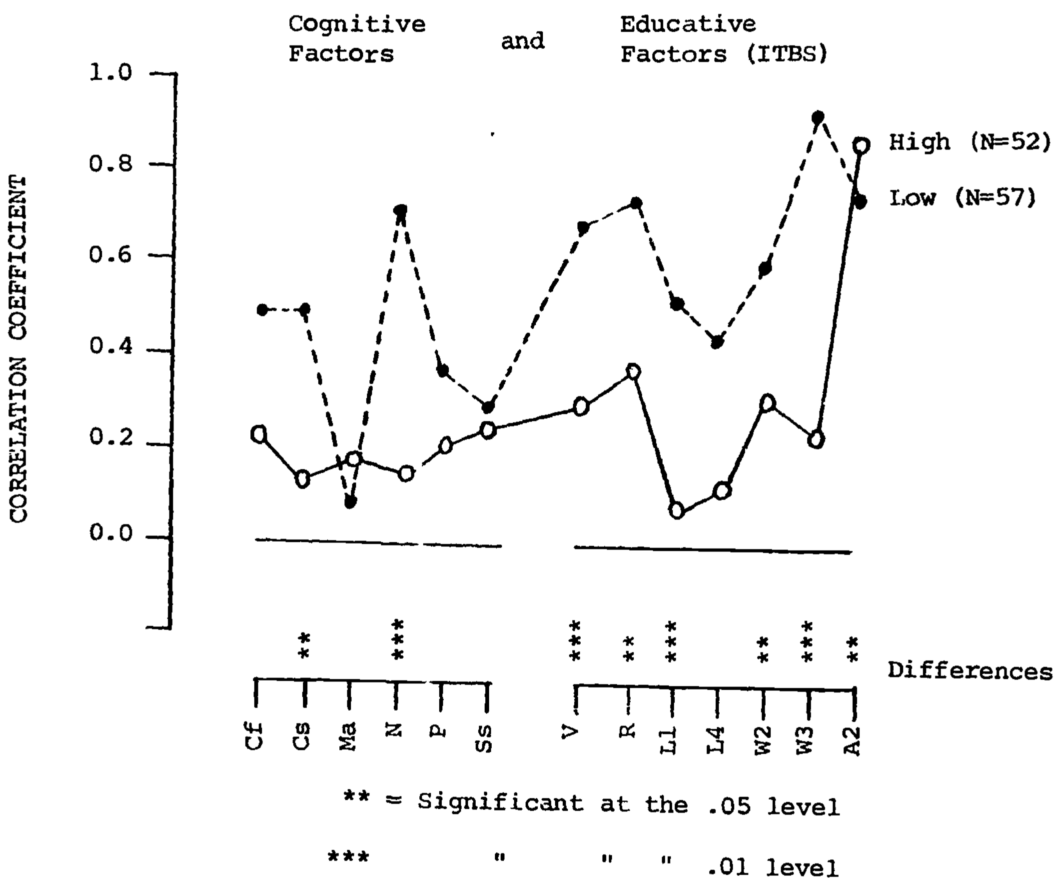
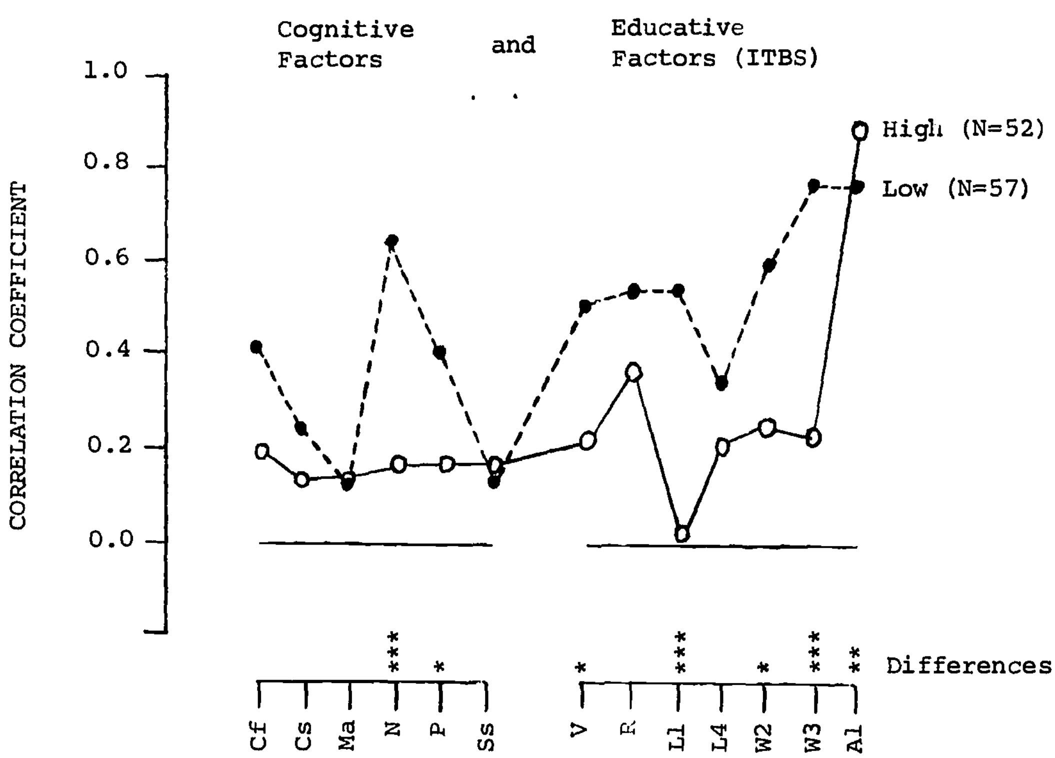


Figure 2. Arithmetic concept CEIs of high- and low-achieving eighth-grade students.



* = Significant at the .10 level

** = " " " .05 level

*** = " " " .01 level

Figure 3. Arithmetic problem solving CEIS of high- and low-achieving eighth-grade students.

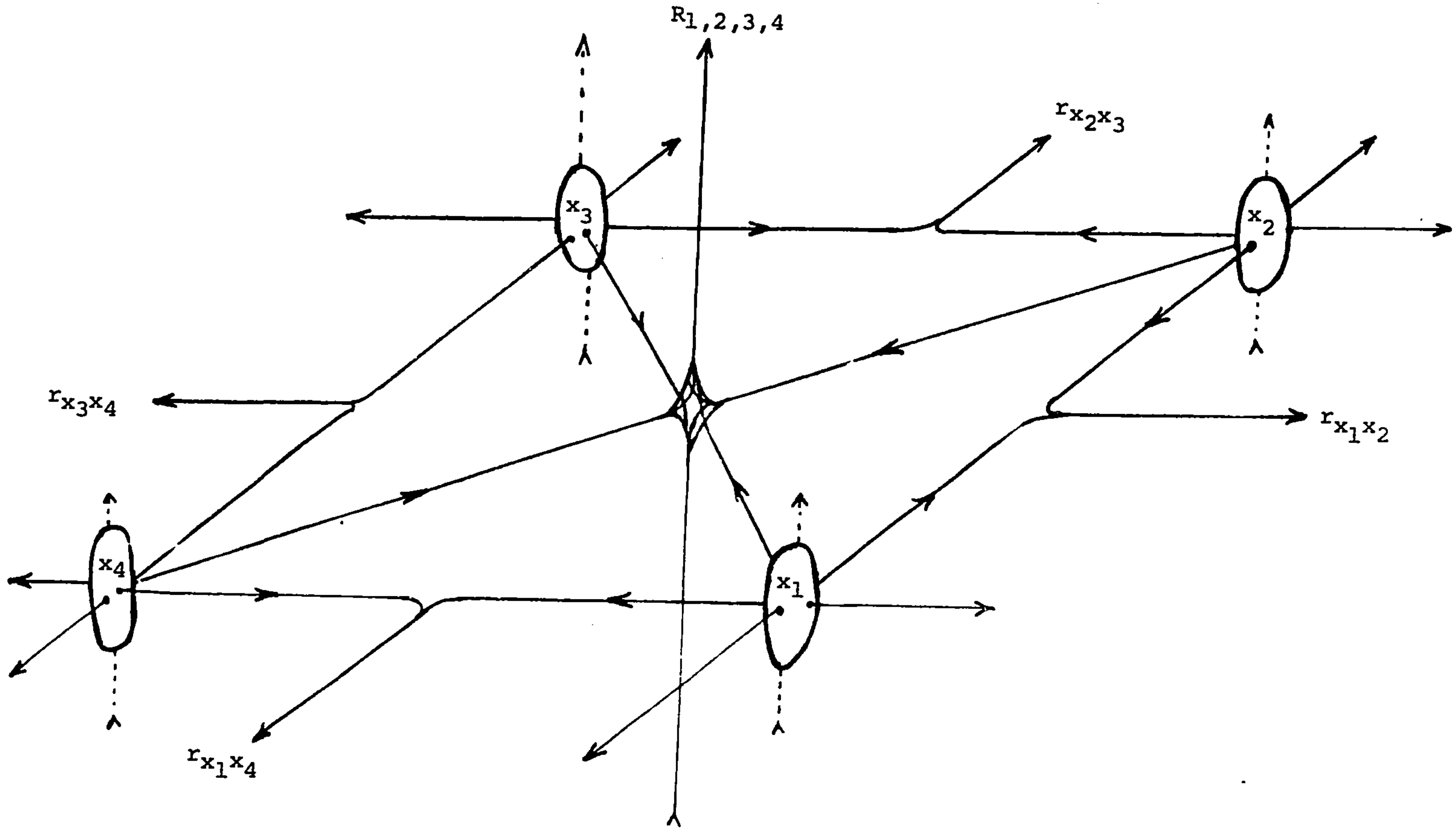


Figure 4. Pictorial representation of the integrative inputs/output functions of the proposed Homomorphic Psychometric Model (HPM).

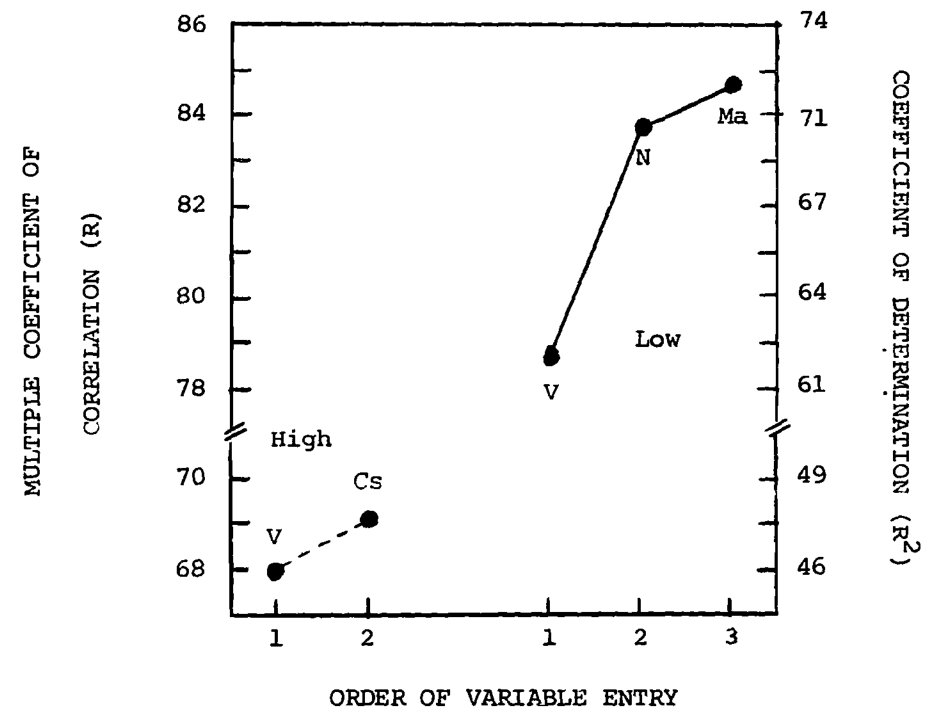


Figure 5. Significant contributors from the set of cognitive variables (N=6) and vocabulary subtest (ITBS) to the prediction of reading comprehension performance scores (ITBS).

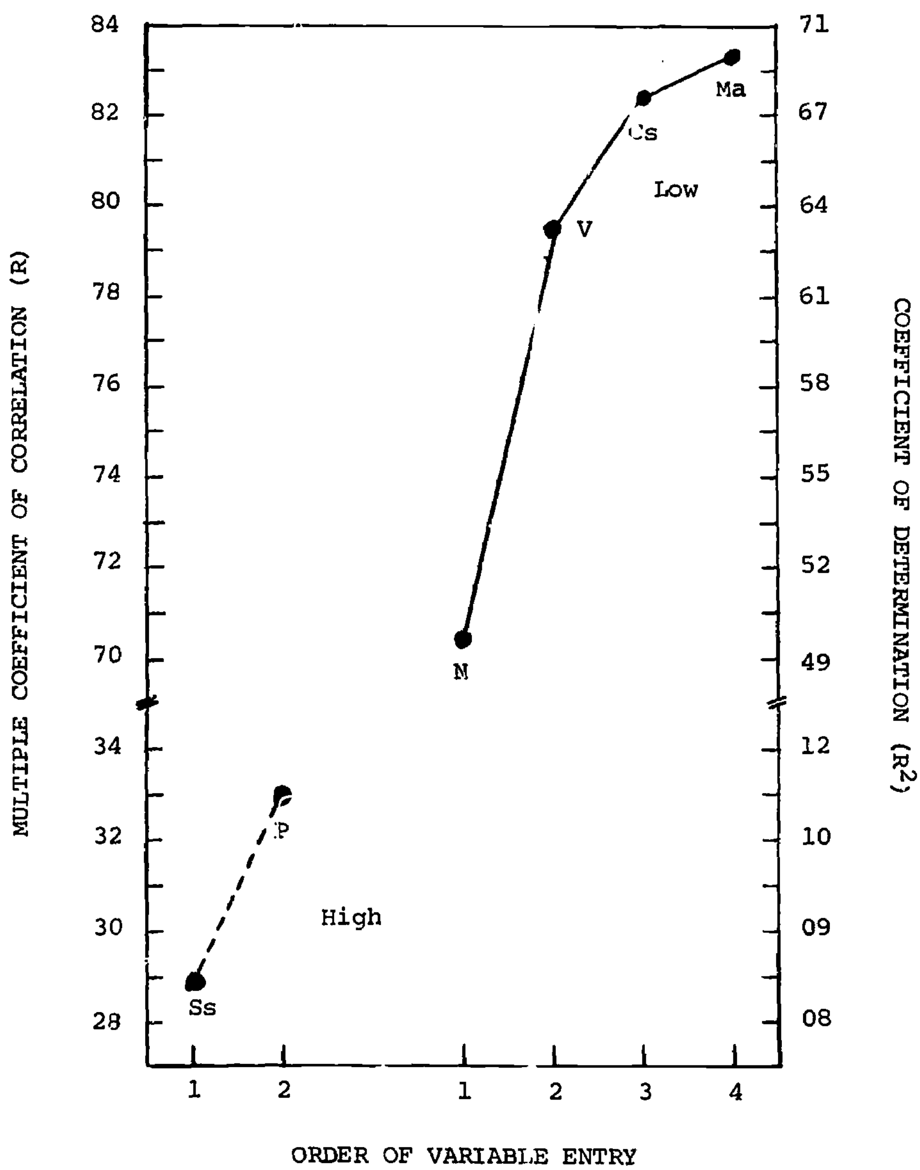


Figure 6. Significant contributors from the set of cognitive variables (N=6) and vocabulary subtest (ITBS) to the prediction of arithmetic concepts performance scores (ITBS).

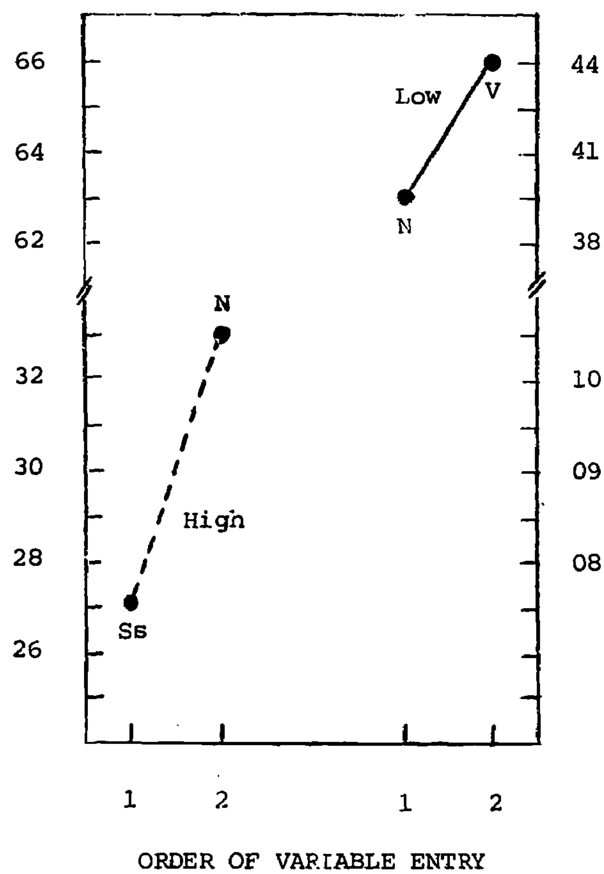


Figure 7. Significant contributors from the set of cognitive variables (N=6) and vocabulary subtest (ITBS) to the prediction of arithmetic problem solving performance scores (ITBS).

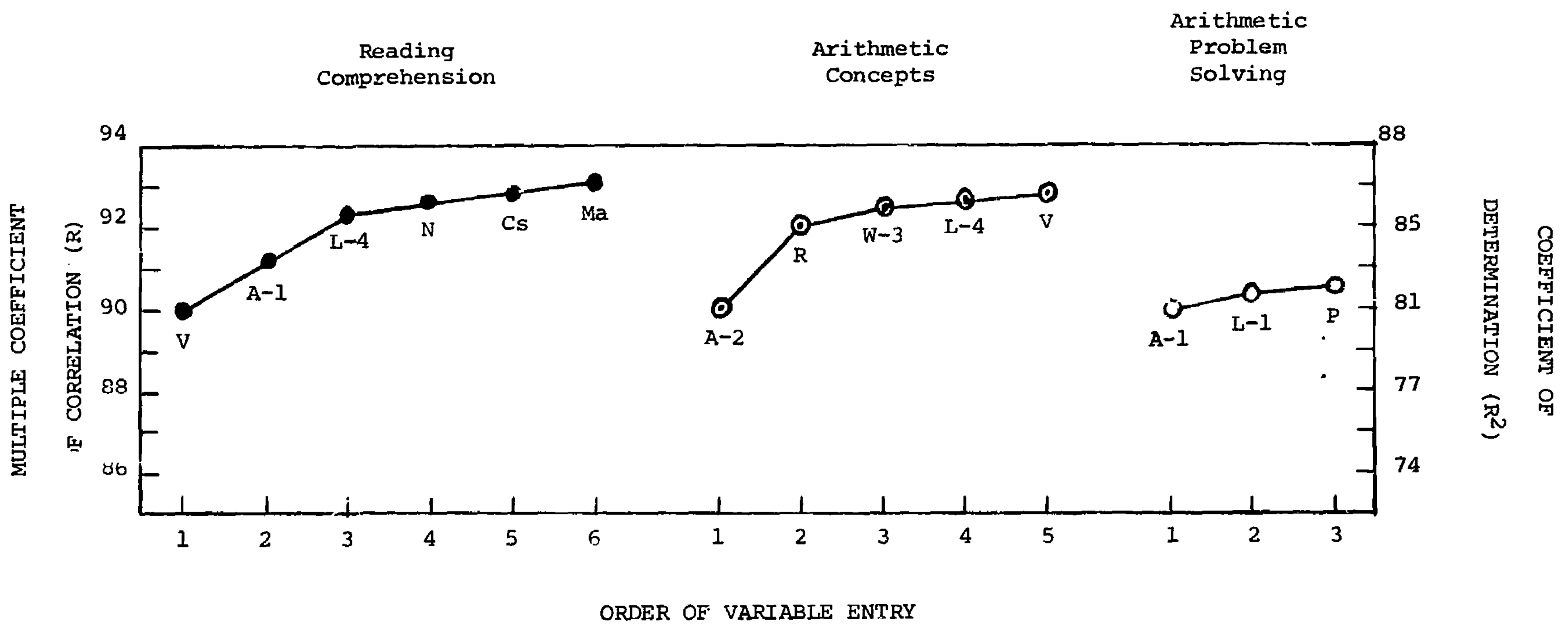


Figure 8. Significant contributors ($p<.05$) to the prediction of reading comprehension, arithmetic concepts, and arithmetic problem solving performance scores of the combined groups (all variables, N=13).

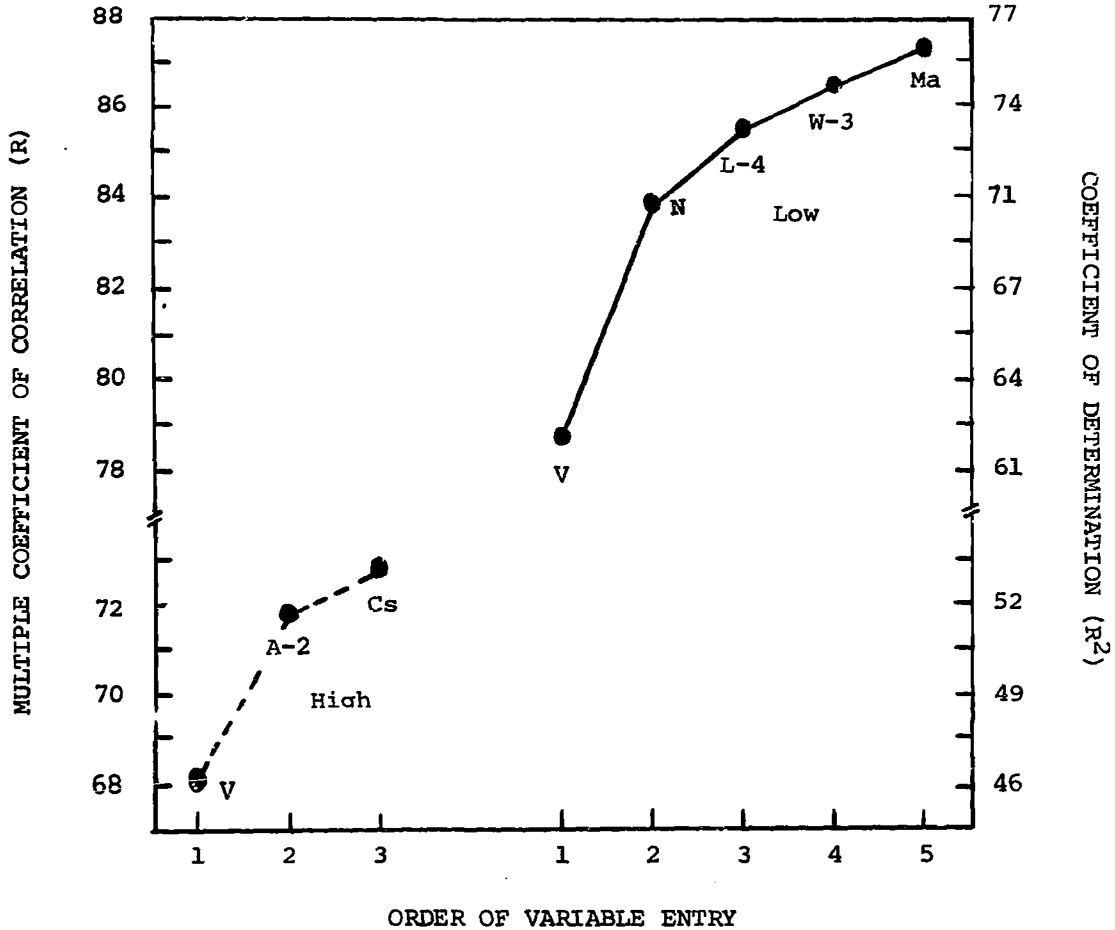


Figure 9. Significant contributors ($p < .05$) to the prediction of reading comprehension performance scores of high- and low-achieving eighth-grade students.

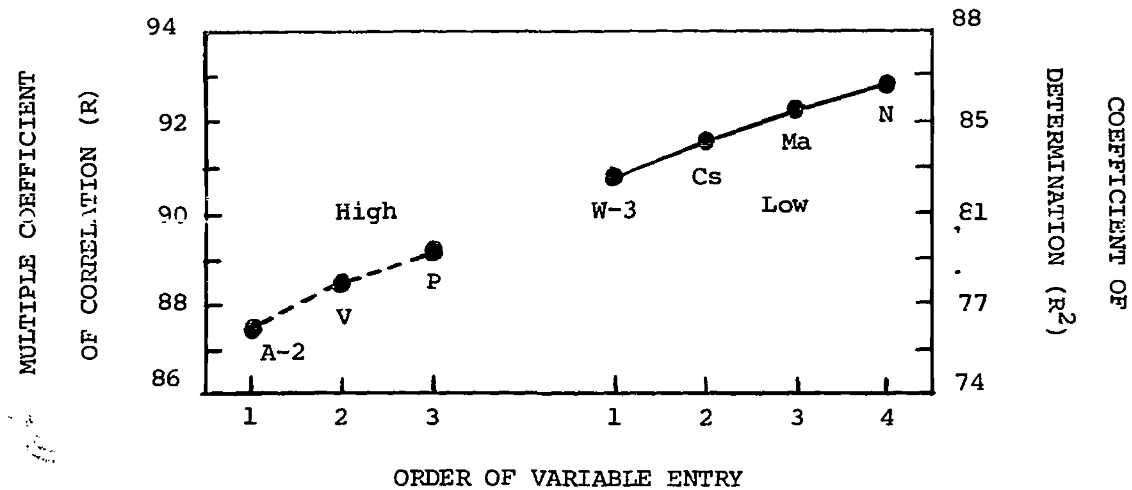


Figure 10. Significant contributors ($p < .05$) to the prediction of arithmetic concepts performance scores of high- and low-achieving eighth-grade students.

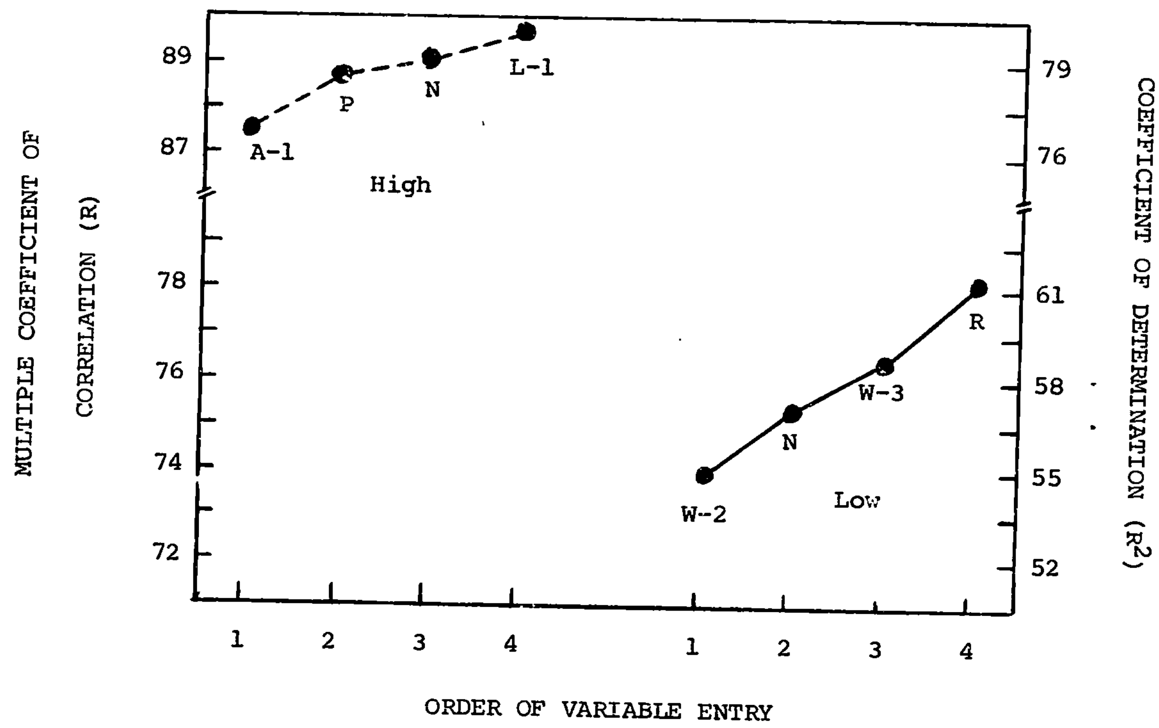


Figure 11. Significant contributors ($p<.05$) to the prediction of arithmetic problem solving performance scores of high- and low-achieving eighth-grade students.

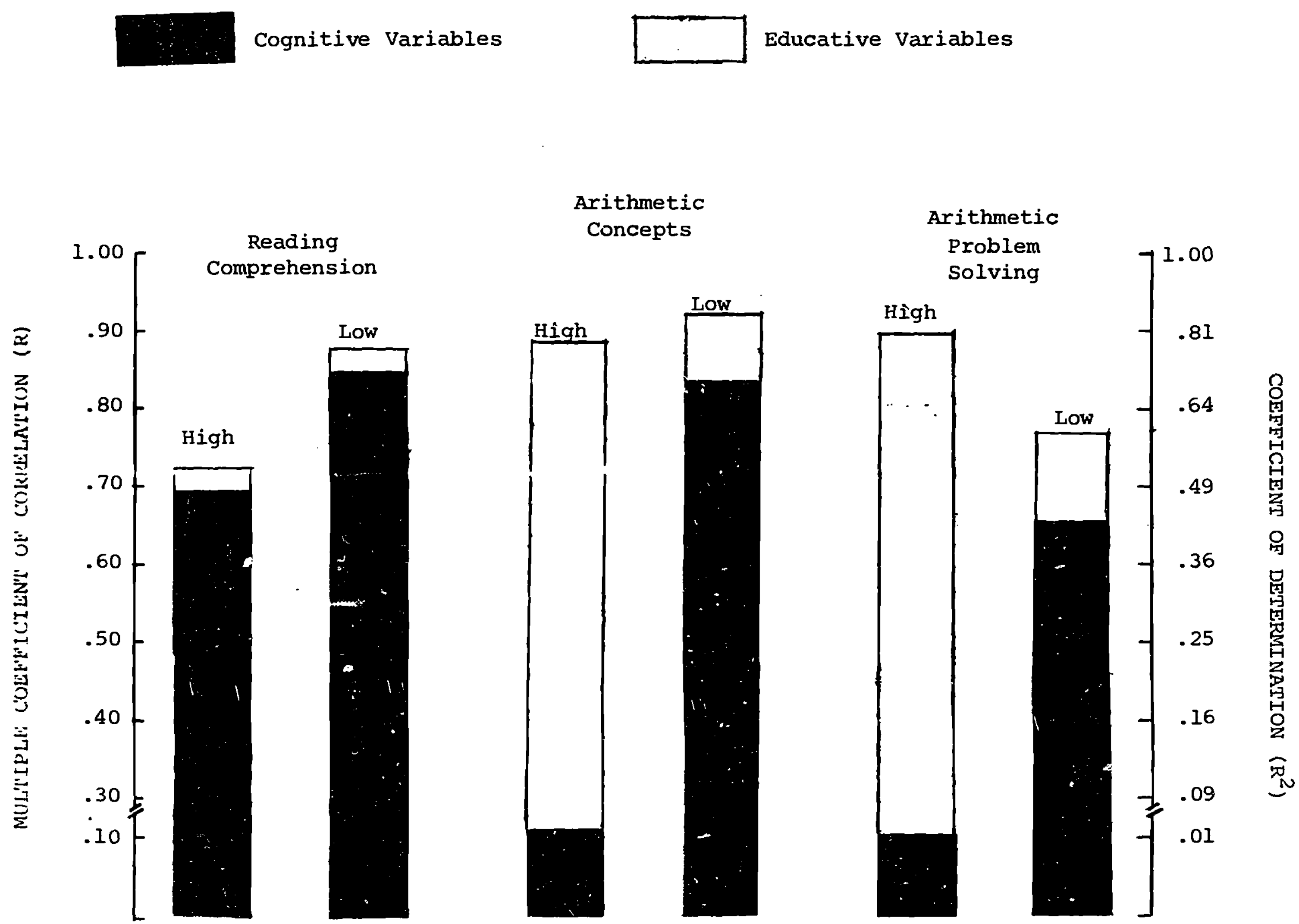


Figure 12. Proportional contributions of cognitive and educative variables to the prediction of reading comprehension, arithmetic concepts and problem solving performance scores (ITBS) of high- and low-achieving eighth-grade students.

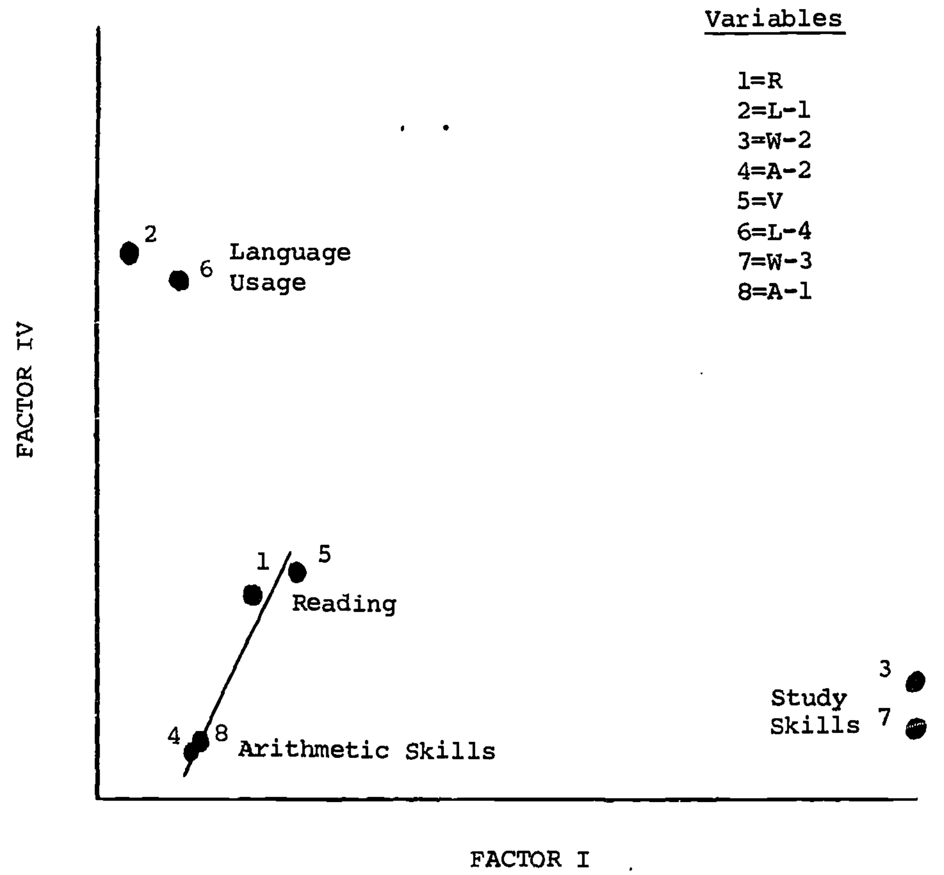


Figure 13. Factor clusters of eight subtests of the Iowa Tests of Basic Skills - high achievers

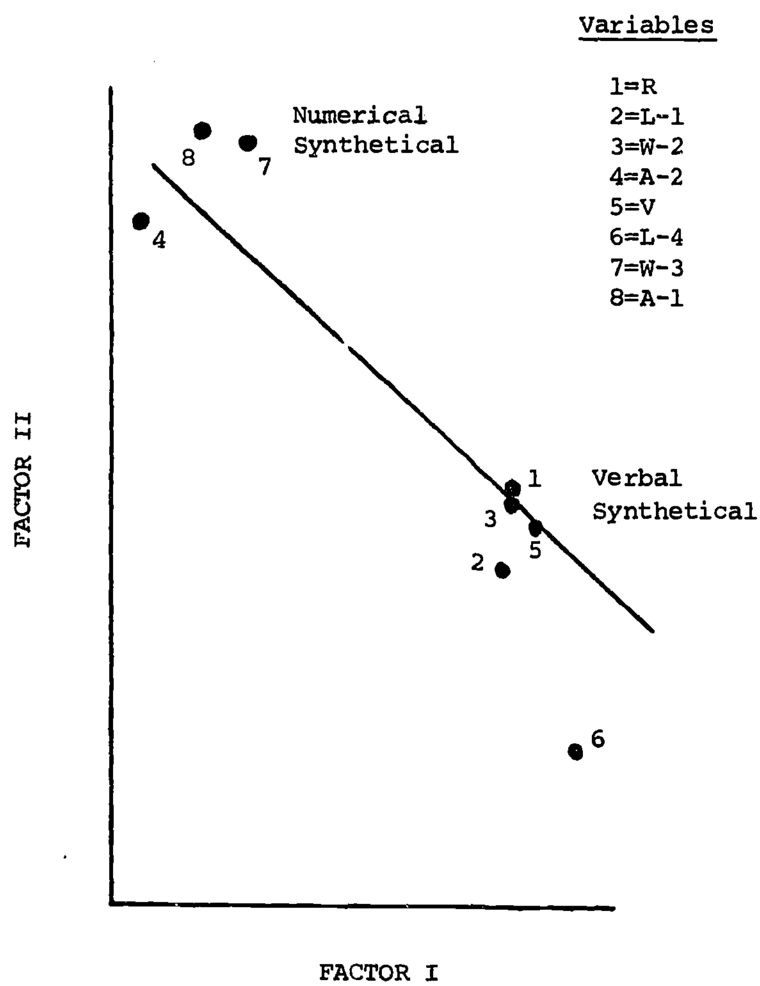


Figure 14. Factor clusters of eight subtests of the Iowa Tests of Basic Skills - low-achievers.

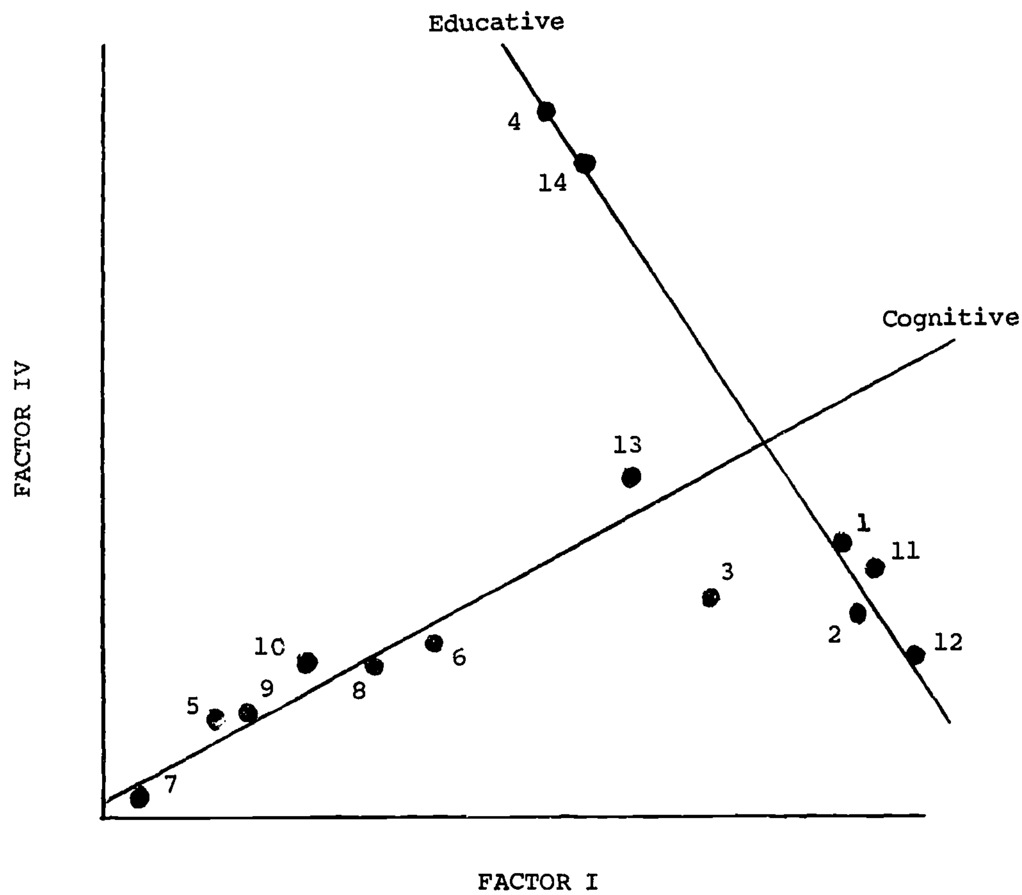


Figure 15. Factor clusters of six cognitive and eight educative skills (Iowa Tests of Basic Skills) - combined samples.

Variables: 1=R, 2=L-1, 3=W-2, 4=A-2, 5=Cf-2, 6=Cs-1, 7=Ma-2, 8=N-3, 9=P-3, 10=Ss-1, 11=V, 12=L-4, 13=W-3, 14=A-1

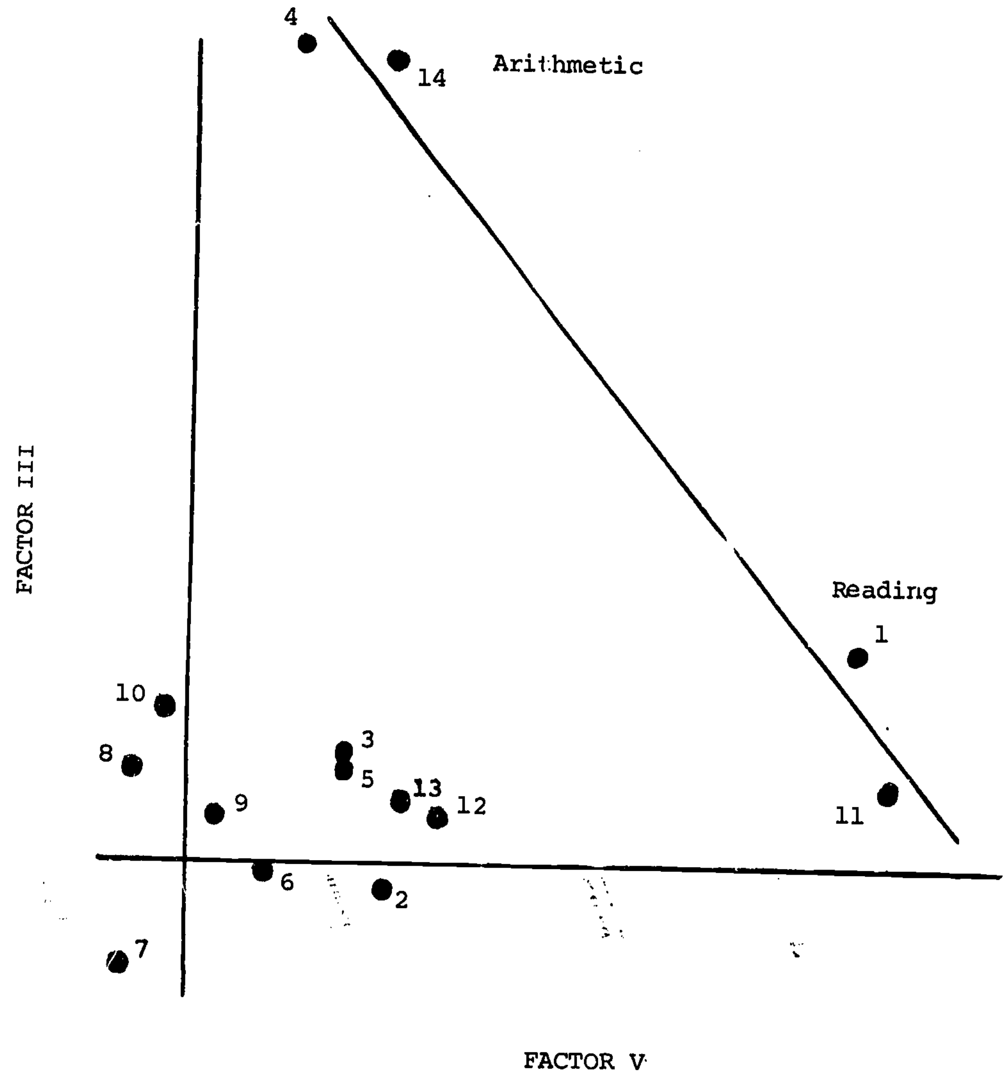


Figure 16. Factor clusters of six cognitive and eight educative skills (Iowa Tests of Basic Skills) - high achievers.

Variables: 1=R, 2=L-1, 3=W-2, 4=A-2, 5=Cf-2, 6=Cs-1, 7=Ma-2, 8=N-3, 9=P-3, 10=Ss-1, 11=V, 12=L-4, 13=W-3, 14=A-1.

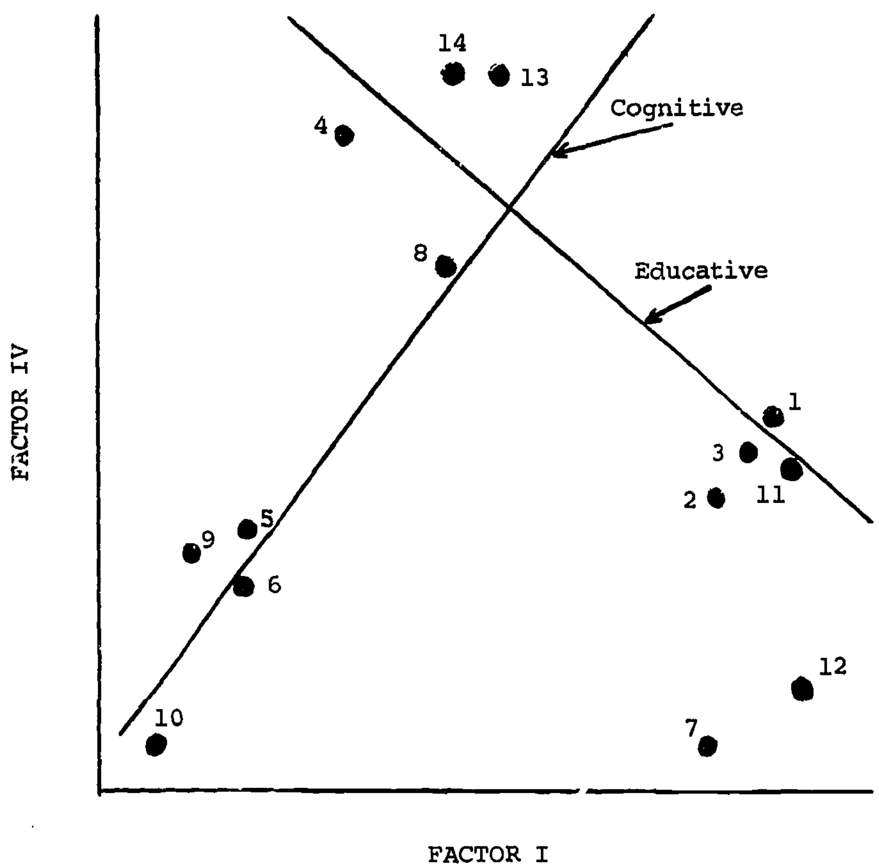


Figure 17. Factor clusters of six cognitive and eight educative skills (Iowa Tests of Basic Skills) - low achievers.

Variables: 1=R, 2=L-1, 3=W-2, 4=A-2, 5=Cf-2, 6=Cs-1, 7=Ma-2, 8=N-3, 9=P-3. 10=Ss-1, 11=V, 12=L-4, 13=W-3, 14=A-1.

TABLE 1

Means, Standard Deviations, and Variance Comparisons of Iowa Tests of Basic Skills Subtest Scores of High- and Low-Achieving Eighth-Grade Students[a]

Subtest	Student Classification				F-ratio Comparison of Group Variances
	High Achievers (N=52)		Low Achievers (N=57)		
	Mean	S.D.	Mean	S.D.	
Vocabulary (V)	9.6	1.0	6.0	1.7	2.07***
Reading Comprehension (R)	9.5	1.1	6.1	1.8	2.92***
Spelling (L-1)	9.6	1.1	5.8	2.2	3.89***
Language Usage (L-4)	9.5	1.2	5.2	2.2	3.83***
Reading Graphs & Tables (W-2)	9.6	1.8	6.0	2.2	1.45
Knowledge and Use of Reference Materials (W-3)	9.8	1.7	6.3	2.1	1.54
Arithmetic Concepts (A-1)	9.0	1.8	5.7	1.9	1.14
Arithmetic Problem Solving (A-2)	9.4	1.8	5.3	1.7	1.10

[a]Form 3, Level F (Spring, 1968).

***$p < .01$

TABLE 2

Means, Standard Deviations, and _t_ Values of Cognitive Factor Test Scores of High- and Low-Achieving Eighth-Grade Students

	Student Classification				
	High Achievers (N=52)		Low Achievers (N=57)		
Cognitive Factor Tests[a]	Mean	S.D.	Mean	S.D.	_t_ Value[b]
Flexibility of Closure (Cf-2)	27.8	7.8	24.2	13.4	1.44 (n.s.)
Speed of Closure (Cs-1)	58.9	20.6	27.3	22.4	28.90***
Associative Memory (Ma-1)	79.5	32.8	76.9	39.8	.07 (n.s.)
Numerical Facility (N-3)	295.0	75.4	236.3	154.8	3.10***
Visual Discrimination (P-3)	309.0	61.4	271.6	70.9	4.24***
Maze Tracing Speed (Ss-1)	88.4	26.7	60.1	25.2	15.88***

[a]French, Ekstrom, and Price, Reference Tests for Cognitive Factors (Revised), Princeton, N. J.: Educational Testing Service, 1963.

[b]Differences calculated using the pooled variance technique (Wert, Neidt, and Ahmann, 1954, pp. 135-137).

***$p < .01$

TABLE 3

Intercorrelations Among and Reliability Coefficients of Six Cognitive and

Eight Educative Variables for High-Achieving Eighth-Grade Students

Iowa Tests of Basic Skills	V	R	L-1	L-4	W-2	W-3	A-1	A-2	Cf-2	Cs-1	Ma-1	N-3	P-3	Ss-1
Vocabulary (V)	(85)[a]	680	276	286	338	423	290	189	318	041	-053	077	097	066
Reading Comprehension (R)		(86)	196	322	337	329	381	354	207	159	-012	000	104	045
Spelling (L-1)			(86)	447	164	080	085	024	031	079	386	363	131	-213
Language Usage (L-4)				(79)	172	196	126	172	-003	068	081	369	180	-067
Reading Graphs and Tables (W-2)					(68)	897	273	232	517	332	131	023	197	283
Knowledge and Use of Reference Materials (W-3)						(84)	217	209	529	309	085	038	114	270
Arithmetic Concepts (A-1).							(84)	873	194	030	141	083	081	177
Arithmetic Problem Solving (A-2)								(69)	237	114	190	185	207	267
Cognitive Factor Tests														
Flexibility of Closure (Cf-2)									(671)[b]	243	043	-106	475	432
Speed of Closure (Cs-1)										(660)	400	-224	293	357
Associate Memory (Ma-1)											(696)	091	196	174
Numerical Facility (N-3)												(861)	189	-039
Visual Discrimination and Recognition (P-3)													(846)	246
Maze Tracing Speed (Ss-1)														(825)

[a]Reliabilities - split-half. Source: Iowa Tests of Basic Skills, Technical Manual, 1964.

[b]Reliabilities of equivalence using alternate forms of Cognitive Factor Tests. (See Cronbach, 1963)

TABLE 4

Intercorrelations Among and Reliability Coefficients of Six Cognitive and Eight Educative Variables for Low-Achieving Eighth-Grade Students

Iowa Tests of Basic Skills	V	R	L-1	L-4	W-2	W-3	A-1	A-2	Cf-2	Cs-1	Ma-1	N-3	P-3	Ss-1
Vocabulary (V)	(85)[a]	789	658	621	693	679	674	471	353	339	113	508	233	196
Reading Comprehension (R)		(86)	592	658	679	733	711	496	390	374	089	648	254	220
Spelling (L-1)			(86)	600	646	590	520	495	382	148	332	655	337	071
Language Usage (L-4)				(79)	621	475	411	319	416	251	134	632	389	621
Reading Graphs and Tables (W-2)					(68)	624	615	553	365	301	-024	465	344	143
Knowledge and Use of Reference Materials (W-3)						(84)	908	740	416	251	134	632	389	197
Arthimetic Concepts (A-1)							(84)	727	480	481	093	705	384	674
Arithmetic Problem Solving (A-2)								(69)	416	251	134	632	389	131
Cognitive Factor Tests														
Flexibility of Closure (Cf-2)									(833)[b]	482	315	522	445	406
Speed of Closure (Cs-1)										(585)	084	299	194	366
Associative Memory (Ma-1)											(721)	351	412	-001
Numerical Facility (N-3)												(908)	478	191
Visual Discrimination and Recognition (P-3)													(710)	305
Maze Tracing Speed (Ss-1)														(726)

[a]Reliabilities - split-half. Source: Iowa Tests of Basic Skills, Technical Manual, 1964.

[b]Reliabilities of equivalence using alternate forms of Cognitive Factor Tests. (See Cronbach, 1963)

TABLE 5

Analogues Among Neurological, Psychometric, and Psychological Hierarchies of Learning

Neuro-psychological (Hebb)	Homomorphic Psychometric (Brown)	(Jensen)	Learning Sets (Harlow & Gagne)	Structure of Intellect (Guilford)	Cognitive Domain (Bloom)	Learning Episodes (Bruner)	Cognitive Development (Piaget)
Constellations			Pre-requisite Abilities and Skills		Knowledge of Specifics	Basic Abilities and Skills	Preoperational
Assemblies	Zero Order Correlations	Level I	Simple Sets	CFU		Concrete Thinking	Concrete Operational
	Multiple Correlations	Level II					
Phases	Basic Factors						
Complex Inter-facilitation	Multiple Factors	Level (n)	Complex Sets	EBI	Judgments; External Criteria	Intuitive Thinking	Formal Operational

TABLE 6

Multiple Predictors and Prediction Equations for Reading Comprehension, Arithmetic Concepts and Problem Solving Performance Scores of High- and Low-Achieving Eighth-Grade Students Using Vocabulary and Six Coginitive Factor Scores

Criterion	High Achievers (N=52) Predictor Variable	Multiple Correlation Coefficient	Cumulative Proportion of Total Variance	Low Achievers (N=57) Predictor Variable	Multiple Correlation Coefficient	Cumulative Proportion of Total Variance
Reading Comprehension (R)	V	6805[a]	4630	V	7886	6219
	Cs	6930	4803	N	8390	7040
	-----(1) Ss	6949	4828	Ma	8456	7151
				-----(1) Cs	8484	7198
				P	8489	7207
Arithmetic Concepts (A-1)	Ss	2899	0841	N	7048	4968
	P	3305	1092	V	7946	6314
	----- Cs	3553	1262	Cs	8206	6735
	Cf	3680	1354	Ma	8317	6917
				-----(2) P	8367	6996
Arithmetic Problem Solving (A-2)	Ss	2699	0712	N	6323	3998
	N	3309	1095	V	6556	4298
	-----(3) V	3659	1339	-----(3) P	6633	4399
	Ma	3914	1532	Ma	6733	4533
	Cf	4064	1652	Cf	6767	4580
				Ss	6817	4647

Prediction Equations

	High Achievers	Low Achievers
(1)	$Y=26.08498+.67967X_1+.06761X_2$	$Y=14.88446+.65605X_1+.04416X_2-.05140X_3$
(2)	$Y=60.57532+.18125X_1+.04569X_2$	$Y=19.20815+.06155X_1+.39904X_2+.18465X_3-.06826X_4$
(3)	$Y=38.59656+.47929X_1+.10728X_2$	$Y=27.17473+.20572X_1+.05891X_2$

[a]Decimal points omitted

TABLE 7

Multiple Predictors and Prediction Equations for Reading Comprehension

Performance of High- and Low-Achieving Eighth-Grade Students

Using Six Cognitive and Eight Educative Variables

	High Achievers (N=52)			Low Achievers (N=57)		
Criterion	Predictor Variable	Multiple Correlation Coefficient	Cumulative Proportion of Total Variance	Predictor Variable	Multiple Correlation Coefficient	Cumulative Proportion of Total Variance
Reading Comprehension (R)	V	6805[a]	4630	V	7886	6219
	A-2	7183	5159	N	8390	7040
	Cs	7262	5274	L-4	8545	7301
	------(1)	------	------			
	Ss	7338	5384	W-3	8651	7483
	L-4	7387	5457	Ma	8738	7635
				------(2)	------	------
	N	7469	5578	A-2	8780	7709
	Ma	7492	5612	L-1	8803	7750
	Gf	7511	5641	W-2	8829	7794
	W-2	7553	5705	P	8834	7804
	W-3	7667	5879	Cs	8837	7810
	A-1	7700	5929			

Prediction Equations

(1) $Y=18.69315+.63843X_1+.13344X_2+.05546X_3$

(2) $Y=12.08475+.41358X_1+.02690X_2+.19363X_3+.19217X_4-.06055X_5$

[a]Decimal points omitted.

TABLE 8

Multiple Predictors and Prediction Equations for Arithmetic Concepts

Performance Scores of High- and Low-Achieving Eighth-Grade Students

Using Six Cognitive and Eight Educative Variables

	High Achievers (N=52)			Low Achievers (N=57)		
Criterion	Predictor Variable	Multiple Correlation Coefficient	Cumulative Proportion of Total Variance	Predictor Variable	Multiple Correlation Coefficient	Cumulative Proportion of Total Variance
Arithmetic Concepts (A-1)	A-2	8735[a]	7630	W-3	9077	8240
	V	8827	7792	Cs	9163	8396
	P	8896	7915	Ma	9222	8504
	------(1)	------	------	N	9228	8628
	N	8923	7963	------(2)	------	------
	L-1	8953	8016	Ss	9311	8670
	Cs	8991	8084	A-2	9334	8712
	W-2	9016	8128	V	9351	8745
	W-3	9084	8253	L-1	9367	8774
	R	9096	8273	P	9375	8790
	Cf	9101	8283	L-4	9379	8797
				Cf	9382	8803

Prediction Equations

(1) $Y=1.32135+.89093X_1+.23433X_2-.03318X_3$

(2) $Y=12.69461+.67454X_1+.11261X_2-.06648X_3+.02021X_4$

[a]Decimal points omitted.

TABLE 9

Multiple Predictors and Prediction Equations for Arithmetic Problem Solving

Performance Scores of High- and Low-Achieving Eighth-Grade Students

Using Six Cognitive and Eight Educative Variables

Criterion	High Achievers (N=52) Predictor Variable	Multiple Correlation Coefficient	Cumulative Proportion of Total Variance	Low Achievers (N=57) Predictor Variable	Multiple Correlation Coefficient	Cumulative Proportion of Total Variance
Arithmetic Problem Solving (A-2)	A-1	8735[a]	7630	W-2	7399	5474
	P	8842	7818	N	7543	5689
	N	8887	7898	W-3	7627	5817
	L-1	8949	8009	R	7821	6116
	------(1)	------	------	------(2)	------	------
	Ss	9003	8103	A-1	7888	6222
	V	9020	8136	Cs	7925	6281
	-R	9057	8203	V	7940	6305
	Cs	9072	8230	L-4	7948	6317
	W-2	9083	8250	Cf	7953	6326
	W-3	9150	8373	Ss	7959	6334
	Cf	9157	8386			
	Ma	9163	8396			
	L-4	9167	8403			

Prediction Equations

(1) $Y=8.33507+.84292X_1+.03044X_2+.03666X_3-.18077X_4$

(2) $Y=21.07481+.48696X_1+.03050X_2+.19133X_3-.27616X_4$

[a]Decimal points omitted.

TABLE 10

Proportional Changes in the Quality of the Prediction of Reading, Arithmetic Concept and Problem Solving Performance Scores of High- and Low-Achieving Eighth-Grade Students Due to the Addition of Educative Predictor Variables

Criterion	Regression Equations	High Achievers (N=52)			Low Achievers (N=57)		
		Cognitive Variables	Educative and Cognitive Variables	Increase in Proportion of Explained Variance	Cognitive Variables	Educative and Cognitive Variables	Increase in Proportion of Explained Variance
Reading	Significant[a]	4803[c]	5274	0471	7151	7635	0484
	Saturated[b]	4828	5929	1101	7207	7810	0593
Arithmetic Concepts	Significant	1092	7915	6823***	6917	8628	1711
	Saturated	1354	8283	6929***	6996	8803	1807**
Arithmetic Problem Solving	Significant	1095	8009	6914***	4298	6116	1818**
	Saturated	1652	8403	6751***	4647	6334	1687**

[a]Variables which contributed significantly ($p \leq .05$) to the prediction of the criterion.

[b]Maximum regression of prediction variables (N=13) on the criterion.

[c]Proportion of explained variance (R^2).

***$p < .01$

**$p < .05$

TABLE 11

Factor Structures Underlying Eight Subtests of the Iowa Tests of Basic Skills

for High- and Low-Achieving Eighth-Grade Students

Variable	Factors: High Achievers[a]					Factors: Low Achievers[b]			
	I	II	III	IV	h^2	I	II	III	h^2
R	1709	2536	6848	2262	6136	6948	4609	3109	7918
V	2248	1023	7277	2514	6538	7253	4207	2220	7524
L-1	0458	-0018	1242	5988	3761	6823	3722	-0877	6117
L-4	0890	0869	1835	5745	3792	7566	1699	0654	6054
A-1	1136	8835	1955	0566	8348	3511	8448	2104	8780
A-2	1008	8994	1167	0544	8356	2804	7470	-1100	6488
W-2	8998†	1405	1488	1304	8671	6946	4370	-0254	6741
W-3	9020	0862	2333	0677	8801	4043	8411	1570	8955

†Significant variable loading (SVL) = value $\geq$ 300.

Identification of Factors

[a]Factor I: Work-Study Skills

Factor II: Arithmetic Skills

Factor III: Reading Comprehension

Factor IV: Language Skills

[b]Factor I: General Verbal-Synthetical Functions

Factor II: General Numerical-Synthetical Functions

Factor III: ?

TABLE 12

Factor Structures Underlying Six Cognitive and Eight Educative Ability Scores of a Combined Sample of High- and Low-Achieving Eighth-Grade Students (N=109)

	Variable	Factors										
		I	II	III	IV	V	VI	VII	VIII	IX	X	h^2
Educative Abilities	R	8104†	-0352	1147	1818	0848	3054†	1402	2086	1120	1120	9495
	V	8541†	-0161	1326	0776	0815	2774	1488	1505	1308	2214	9478
	L-1	8340†	1708	0967	2451	1132	2195	0471	1005	1099	-2107	9239
	L-4	8878†	0494	-0124	1329	0972	1719	1515	1538	0534	-1259	9127
	A-1	5332†	0130	1245	1849	0925	7174†	1726	1804	1458	1092	9528
	A-2	4994†	0417	0950	1458	1508	7770†	1650	1358	1221	-0766	9695
	W-2	6664†	-0422	1786	0603	1583	2403	1414	1724	5850†	-0892	9646
	W-3	0579	0579	2022	2091	0812	3741†	1572	2212	5235†	1618	9493
Cognitive Abilities	Cf	1236	0995	9189†	1592	1927	1097	1690	1301	0936	^087	9984
	Cs	3674†	0919	1626	0198	1080	1936	2334	8446†	1171	0100	9991
	Ma	0445	9787†	0812	1004	1308	0208	0120	0589	-0001	-0046	9978
	N	3021†	1316	1711	8917†	1668	1746	0248	0182	0652	0073	9966
	P	1626	1609	1930	1549	9171†	1223	1328	0881	0652	0032	9992
	Ss	2254	0145	1738	0258	1356	1726	9096†	1876	0783	0094	9988

† SVL $\geq$ 300.

TABLE 13

Combined Data
Factor I: General Educative Skill

Test	Factor Coefficient
Language Usage (L-4)	8878
Vocabulary (V)	8541
Spelling (L-1)	8340
Reading Comprehension (R)	8104
Reading Graphs and Tables (W-2)	6664
Arithmetic Concepts (A-1)	5332
Arithmetic Problem Solving (A-2)	4994
Speed of Closure (Cs)	3674
Numerical Facility (N)	3021

TABLE 14

Combined Data
Factor VI: General Arithmetic Operations

Test	Factor Coefficient
Arithmetic Problem Solving (A-2)	7770
Arithmetic Concepts (A-1)	7174
Knowledge and Use of Reference Materials (W-3)	3741
Reading Comprehension (R)	3054

TABLE 15

Factor Structures Underlying Six Cognitive and Eight Educative Ability Scores of the High-Achieving Eighth-Grade Students

	Variable	Factors								h^2
		I	II	III	IV	V	VI	VII	VIII	
Educative Abilities	R	1627	0747	2379	0405	7411†	0363	1244	0137	6554
	V	2318	1403	0936	1017	7668†	-0655	-1205	0111	6995
	L-1	0449	5830†	-0386	-0568	2235	3587†	-1193	2764	6159
	L-4	0922	5562†	0461	0226	2846	0880	1676	0388	4388
	A-1	1178	0366	8932†	0232	2090	0510	-0678	0363	8657
	A-2	0744	1196	8952†	1644	1135	0844	0704	-1116	8857
	W-2	8834†	0660	1237	1780	1628	1433	0178	0065	8802
	W-3	8981†	0113	0738	1254	2404	0792	0113	-0781	8981
Cognitive Abilities	Cf	4136†	-1332	1033	6385†	1745	0166	-1049	-0494	6514
	Cs	2127	-1570	-0118	2453	0871	5904†	1814	-1201	5338
	Ma	0306	1638	1165	0805	-0826	6397†	-0788	0179	4704
	N	-0451	6772†	1045	0583	-0588	-0911	-0631	-0367	4902
	P	0353	1975	0533	6433†	0328	1792	-0662	-0040	4946
	Ss	2053	-1728	1752	3982†	-0293	1889	-0146	-3667†	4325

† SVL ≥ 300.

TABLE 16

High-Achieving Students
Factor IV. Cognitive Processing Skill A

Test	Factor Coefficient
Visual Discrimination and Recognition (P)	6433
Flexibility of Closure (Cf)	6385
Maze Tracing Speed (Ss)	3982

TABLE 17

High-Achieving Students
Factor VI. Cognitive Processing Skill B

Test	Factor Coefficient
Associative Memory (Ma)	6397
Speed of Closure (Cs)	5904
Spelling (L-1)	3587

TABLE 18

Factor Structures Underlying Six Cognitive and Eight Educative Ability Scores

of the Low-Achieving Eighth-Grade Students

	Variable	Factors								
		I	II	III	IV	V	VI	VII	VIII	h^2
Educative Abilities	R	7352†	2731	0263	4148†	-0822	1190	1100	-0168	8211
	V	7589†	2227	0402	3511†	-0544	-0683	0081	-1090	7700
	L-1	6684†	-0007	3574†	3283†	0994	0853	2019	-0311	7411
	L-4	7663†	0701	1488	1116	0161	0367	-0540	0569	6345
	A-1	3874†	3716†	0305	7886†	0008	-0108	-0583	-0509	9171
	A-2	2692	1264	1240	7219†	1889	0215	1039	0422	6737
	W-2	7126†	1793	-0606	3692†	2720	-0861	1489	0685	7883
	W-3	4381†	2387	1645	7894†	-0550	-0582	-0325	-0139	9068
Cognitive Abilities	Cf	1575	5761†	3323†	2925	0769	0409	1512	0224	5836
	Cs	1624	5989†	0266	2210	-1183	-0648	0136	0393	4549
	Ma	0674	0408	7329†	0471	-0137	-0022	-0041	0013	5458
	N	3798†	2079	4092†	5838†	0481	2899	0313	0050	7830
	P	1034	3104†	4563†	2598	3726†	0234	0058	-0063	5222
	Ss	0588	5899†	0235	0465	1197	0458	-0491	-0348	3730

† SVL $\geq$ 300.

TABLE 19

Low-Achieving Students
Factor I: General Verbal-Synthetical

Test	Factor Coefficient
Language Usage (L-4)	7663
Vocabulary (V)	7589
Reading Comprehension (R)	7352
Reading Graphs and Tables (W-2)	7126
Spelling (L-1)	6684
Knowledge and Use of Reference Materials (W-3)	4381
Arithmetic Concepts (A-1)	3874
Numerical Facility (N)	3798

TABLE 20

Low-Achieving Students
Factor IV: General Numerical Synthetical

Test	Factor Coefficient
Knowledge and Use of Reference Materials (W-3)	7894
Arithmetic Concepts (A-1)	7886
Arithmetic Problem Solving (A-2)	7219
Numerical Facility (N)	5838
Reading Comprehension (R)	4148
Reading Graphs and Tables (W-2)	3692
Vocabulary (V)	3511
Spelling (L-1)	3283

TABLE 21

Low-Achieving Students
Factor II: Cognitive Processing Skill C

Test	Factor Coèfficient
Speed of Closure (Cs)	5989
Maze Tracing Speed (Ss)	5899
Flexibility of Closure (Cf)	5761
Arithmetic Concepts (A-1)	3716
Visual Discrimination and Recognition (P)	3104

TABLE 22

Low-Achieving Students
Factor III: Cognitive Processing Skill D

Test	Factor Coefficient
Associative Memory (Ma)	7329
Visual Discrimination and Recognition (P)	4563
Numerical Facility	4092
Spelling (L-1)	3574
Flexibility of Closure (Cf)	3323

APPENDIX

Factor Analysis Summary Data

Iowa Tests of Basic Skills

Variable	High-Achievers (N=52)			Low-Achievers (N=57)		
		Factors Rotated[a] (N=4)			Factors Rotated[a] (N=3)	
	Eigen-value	Cumulative Proportion of Total Variance	Iteration Cycles (N=5)	Eigen-value	Cumulative Proportion of Total Variance	Iteration Cycles (N=5)
R	2.9254	.3657	.0928	5.0562	.6320	.0118
L-1	1.2599	.5232	.4624	0.6537	.7137	.1371
W-2	0.8794	.6331	.5583	0.1576	.7334[b]	.1773
A-2	0.3756	.6800[b]	.5615	-0.0199		.1849
V	-0.0066		.5615	-0.0243		.1849
L-4	-0.0453		.5615	-0.0781		.1849
W-3	-0.1476			-0.0958		
A-1	-0.2240			-0.1323		

[a]Only positive Eigenvalues and associated vectors were used in the computation.

[b]Coefficient of Determination (R^2).

Factor Analysis Summary Data

Iowa Tests of Basic Skills and Six Cognitive Ability Factors

Variable	High-Achievers (N=52)			Low-Achievers (N=57)		
		Factors Rotated[a] (N=8)			Factors Rotated[a] (N=8)	
	Eigen-value	Cumulative Proportion of Total Variance	Iteration Cycles (N=8)	Eigen-value	Cumulative Proportion of Total Variance	Iteration Cycles (N=6)
R	3.5827	.2559	.1232	6.4912	.4637	.0932
L-1	1.5982	.3701	.4003	1.1166	.5434	.2863
W-2	1.3016	.4630	.4785	0.8464	.6039	.3118
A-2	1.1066	.5421	.4969	0.5815	.6454	.3250
Cf	0.5848	.5821	.4994	0.2775	.6652	.3270
Cs	0.6255	.6255	.4997	0.1042	.6727	.3271
Ma	0.1673	.6374	.4997	0.0735	.6779	.3271
N	0.0895	.6438[b]	.4997	0.0245	.6797[b]	
P	-0.0118		.4997	-0.0168		
Ss	-010640			-0.0458		
V	-0.1169			-0.0601		
L-4	-0.1637			-0.1267		
W-3	-0.2238			-0.1608		
A-2	-0.2675			-0.2472		

[a]Only positive Eigenvalues and associated vectors were used in the computation.

[b]Coefficient of Determination (R^2).

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